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OUTLINE
WATER RESERVATIONS APPLICATIONS
CUMULATIVE EIS

Contents	Author	Number of Pages
I. INTRODUCTION	Gary Fritz	
A. Water Use Act		3
Reservation authority		
Summary of provisions		
B. MEPA		1
Controversial nature of applications		
Applications represent proposal that would result in significant environmental impact		
Cumulative EIS rather than individual		4
II. DESCRIPTION OF PROPOSED ACTIONS	Gary Fritz	
A. Summary of each application		15
Kind of use		
Amount of water involved		
Place of use		
Time schedule		
Facilities		15
III. EXISTING ENVIRONMENT		
A. Study area	Gary Fritz	1
B. Physical		
Climate	Wayne Wetzel	5
Precipitation		
Temperatures		
Growing season		
Storms		

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Contents	Author	Number of pages
Air Quality	Wayne Wetzel	3
Inversions		
Wind		
Ambient air quality		
Water Resources		
Surface Water	Gary Fritz	20
Description of stream types		
Map of gaging stations		
Flow duration curves		
Mountains		
Plains		
Flood flows		
Hydrographs		
Unit discharge		
Mountains		
Plains		
Effects of man-made structures		
Stock ponds		
Large impoundments		
Channel morphology		
Ground Water	Gary Fritz	3
Aquifer description		
Location and depth		
Yield		

Contents	Author	Number of pages
Water Quality	~~Wayne Wetzel~~ Norm Banard	5
Chemical analysis		
Temperature		
pH		
TDS		
TSS		
BOD		
Others		
Pollution sources		
Municipal		
Industrial		
Agriculture		
Geology	Wayne Wetzel	5
Geomorphology-Phyiography		
Altitude extremes		
Land forms		
Landscape		
General geology		
Mineral resources		
Coal		
Oil		
Gas		
Chromium		
Bentonite		

Contents	Author	Number of pages
Soils	Glenn Smith	5
Derivation		
Types		
Land classification map		
Vegetation	Wayne Wetzel	3
Types		
Distribution		
Fish and Wildlife	Liter Spence	20
Species		
Location		
Population		
Human		
Economic		
Employment	Bill Long	5
By sector		
Unemployment	Bill Long	5
Seasonality		
Skills		
Income	Bill Long	5
By sector		
Transfer payments		
state		
federal		

Contents	Author	Number of pages
Land Use	Bill Long	2
Agriculture		
Industrial		
Recreation		
Urban		
Water Use	Gary Fritz	10
Municipal and Industrial		
Agricultural		
Other		
Social		
Population Size	Bill Long	2
Historical growth		
Population Distribution	Bill Long	2
Rural		
Urban		
Rural non-farm		
Land Tenure and Land Use - Historical Change	Bill Long	3
Agriculture		
Urban		
Industrial		
Forest		
Social Institutions - Historical	Bill Long	1
Church		
Farm Groups		
County Groups		
Education		
Political leanings		

Contents	Author	Number of pages
Special Concerns	Bill Long	1
Livestyles		
Outsiders		
Family (extended)		
Church		
Politics		
Recreation	Mac Roberts	5
Demographic Parameters	Bill Long	2
Housing		
Transportation		
Schools		
[illegible]		
Recreation		
Fire protection		
Social services		
Health services		
Aesthetics, Natural Beauty, and Tranquility	Mark McElwain	5
Archeological and Historical Sites	Mac Roberts	5
		123

IV. LEGAL PROVISIONS

A. Montana Water Laws, Policies, and Administration	Laurence Siroky	3
Water Use Act		
Changes from old law		
Basic provisions		
Adjudication		
Concept		
Procedure		
Moratorium		
Suspended action		
List of affected applications		

Contents	Author	Number of pages
Yellowstone River Compact	Gary Fritz	1
Percentage division		
Point of measurement		
Article X		
Federal Reserved Rights	Ted Doney	1
Federal		
Indian		
Status of litigation		5
		147

IV. IMPACTS OF PROPOSED ACTION

Environmental

Hydrology

Ground water

Alluvial aquifers

Surface water

Water depletions

Hydrograph modifications

Water Quality

Sediment

TDS

Temperature

Channel Form and Process

Vegetation

Islands

Gravel bars

Bank stability

Sediment transport

Riparian Land Use

Interrelated ecological systems

Erosion

Vegetation

Terrestrial and aquatic life

Fish

- Insects
- Waterfowl
- Furbearers

Aesthetics, natural beauty, and tranquility

- Human development
  - Suburban
  - Storage, diversion, and conveyance facilities
- Reduced flows.

Recreation

- Opportunities
- Quality

Archeological and historical sites

Socio-economic

Adverse

- Recreation
- Cost of water
  - Storage
  - Diversion
    - Pumping
    - Gravity
  - Conveyance
  - On-site

Beneficial

- Recreation
  - Type
  - Value
- Agriculture
  - Crop value

Flood damage reduction

Municipal water supply

Hydropower

Soil erosion reduction

Water Rights

Water availability

Effects on existing rights

V. IMPACTS OF ALTERNATIVE ACTIONS

Same as IV

VI. RECOMMENDED ACTION

Proposed Action

Modification

Approval

Denial

VII. RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

IX. AGENCIES, GROUPS AND INDIVIDUALS FROM WHOM COMMENTS HAVE BEEN RECEIVED

X. REFERENCES

XI. INDIVIDUALS CONTRIBUTING TO PREPARATION OF IMPACT STATEMENTS

INTRODUCTION

State and federal agencies, and state political subdivisions, under provision of the 1974 Montana Water Use Act may now apply to the Board of Natural Resources and Conservation to reserve water for existing or future beneficial uses, or to maintain a minimum flow, level or quantity of water. The water reservation, when adopted, is a form of water right but can be modified by the Board if the appropriator does not pursue the use of the water with due diligence.

The Board may not adopt an order reserving water unless the applicant establishes to the satisfaction of the Board:

1) the purpose of the reservation,

2) the need for the reservation,

3) the amount of water necessary for the purpose of the reservation, and

4) that the reservation is in the public interest.

If the use of the reserved water would require diversion or storage structures then a plan that describes those facilities must be submitted with the application. Also the Board must be convinced that the construction of the facilities will be pursued with reasonable diligence.

The Yellowstone Moratorium emphasizes the need for reserving water within the basin for the protection of existing and future beneficial water uses. Water reservations adopted during the three year moratorium will have preference over the large water right applications held pending during the moratorium.

The Montana Environmental Policy Act and guidelines adopted by the Montana Environmental Quality Council require State agencies to prepare environmental impact statements when proposed action may significantly affect the environment, and a statement is specifically required if the action is controversial. Prior to the Board acting on the water reservation applications the Department determined that a cumulative environmental impact statement should be prepared because:

(1) The proposed actions may result in significant environmental impacts, and

(2) The proposed actions are of a controversial nature, and

(3) To wisely allocate Yellowstone waters the cumulative effects of the applications must be identified basin wide.

Proposed Action

DESCRIPTION OF THE PROPOSED ACTIONS

Water reservation applications received prior to November 1, 1976 and requesting water from the Yellowstone River Basin are summarized below in order of their receipt by this Department.

1. Montana Department of Fish and Game

Purpose of the Reservation

As stated in the application, "the purpose of this reservation is to ensure that adequate flows are present in the Yellowstone River to honor all existing water use rights, to support aquatic life as it is now found in the river, to maintain Canada goose and other waterfowl populations,to provide necessary habitat for all forms of wildlife, to sustain high levels of water quality, to provide a water based recreational opportunities and to generally contribute to a clean healthful environment."

Amount of Water Necessary for Purpose of Reservation

The amount requested is based on monthly flows which are equaled or exceeded 70 percent of the time. The requested amounts are shown in the table below.

Month	Reach 1 [1/]		Reach 2 [2/]		Reach 3 [3/]	
	CFS	AF	CFS	AF	CFS	AF
January	2,200	135,275	4,000	246,000	4,500	276,705
February	2,200	126,548	4,000	230,086	5,500	305,470
March	2,600	159,900	6,300	387,450	7,500	461,175
April	3,000	178,500	6,300	274,850	7,500	446,325
May 1-20	6,000	249,920	9,200	383,712	10,000	416,535
May 21-31	11,500	127,810	17,000	370,914	20,000	436,370
June	20,300	1,707,850	30,000	1,785,000	34,000	2,023,340
July 1-20	11,500	479,015	17,000	708,110	20,000	833,020
July 21-31	6,000	130,910	9,200	200,730	10,000	718,200
August	3,800	226,100	5,400	332,100	6,000	368,940
September	3,000	178,500	5,400	321,308	5,500	327,305
October	3,000	184,500	6,000	369,000	6,000	869,000
November	3,000	178,500	6,000	357,000	6,000	357,000
December	2,200	135,275	4,000	246,000	4,500	276,705
ANNUAL	N/A	3,593,605	N/A	6,311,752	N/A	7,116,090

2. Buffalo Rapids Irrigation Project

Purpose of the Reservation

As stated in the application," the purpose of the reservation is to ensure water availability for future expansion of the Buffalo Rapids Irrigation Project." This expansion may take place in any one or a combination of three ways, (a) irrigation of Project lands, not non-irrigated (b) irrigation of lands outside the project and identified by the Bureau of Reclamation, or (c) irrigation of private lands adjacent to the Project.

Description of Lands and Facilities

The reservation includes the following lands originally located by Bureau of Reclamation studies:

Cracker Box	1,740 acres
Stipek	3,840 acres
Marsh	3,190 acres
Haley	2,372 acres
Colgate	760 acres
Sangus-Calypso	450 acres
	12,352 acres

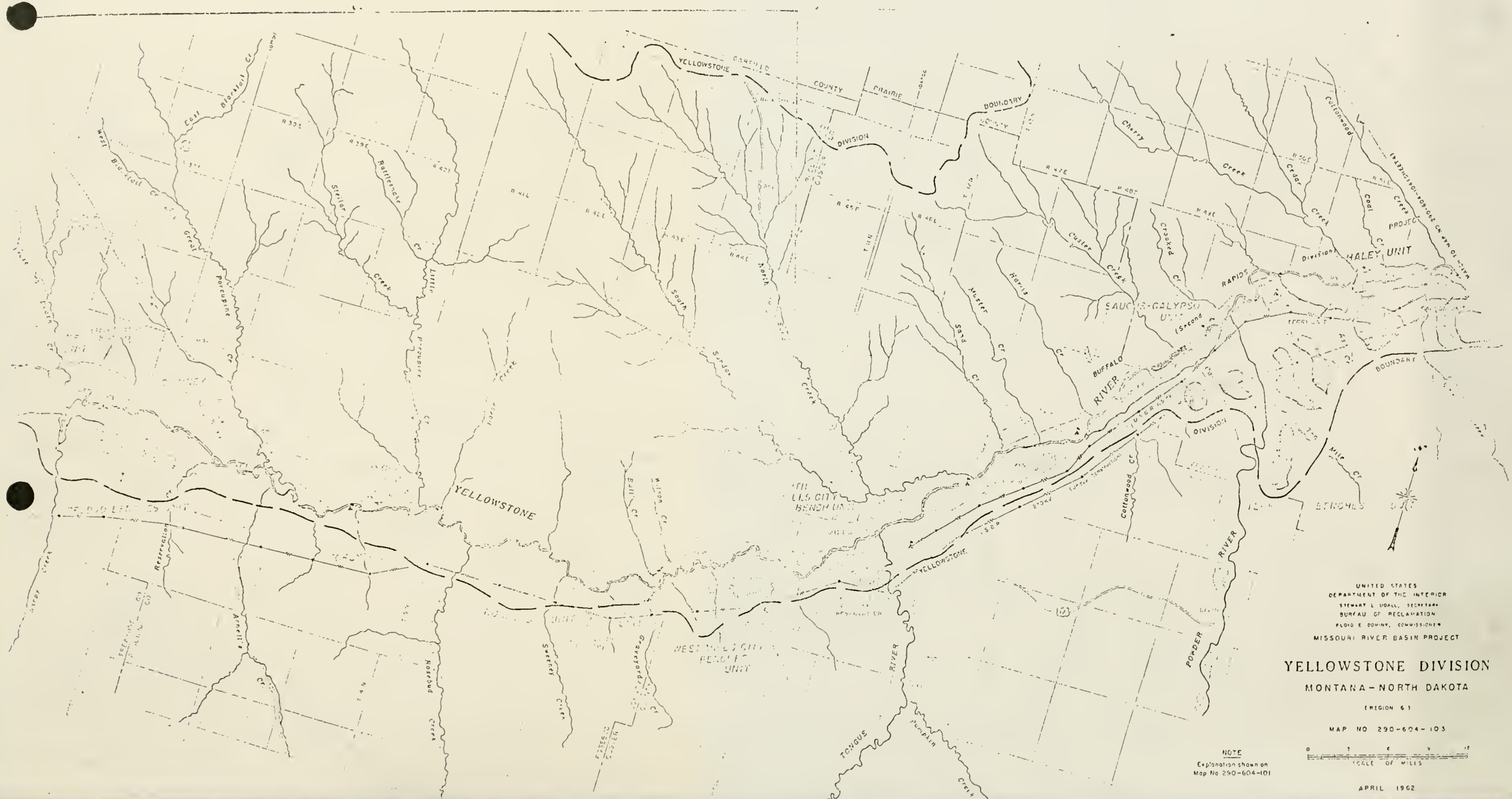
In addition, the request is for water to serve bench lands adjacent to the Project, including lands;

Above Glendive canal	8,500 acres
Terry Bench (Bureau of Reclamation)	
Above Shirley Unit	
Above Terry Unit	17,354 acres
Additional in Terry Unit	1,300 acres
Additional in Fallon Unit	800 acres
Additional in Buffalo Rapids	11,000 acres
	38,954 acres
TOTAL	51,306 acres

The proposed acreages and facilities are shown on the following maps. Facilities were not specified except in cases where the Bureau of Reclamation had done previous studies.

Amount of Water Necessary for the Purpose of the Reservation

The amount of water necessary to irrigate the lands specified above totals 124,434 acre feet and was not distributed monthly in the application.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DEPARTMENT OF THE INTERIOR
STEWART L. UDALL, SECRETARY
BUREAU OF RECLAMATION
FLOYD E. DOMINY, COMMISSIONER
MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION
MONTANA-NORTH DAKOTA
(REGION 6)
MAP NO 290-604-103
NOTE
Explanation shown on
Map No 290-604-101
SCALE OF MILES
APRIL 1962
YELLOWSTONE
RIVER
TONGUE
POWDER
BUFFALO
RAPIDS
HALEY UNIT
BOUNDARY
DIVISION
COUNTY
PRAIRIE
Rosebud Creek
Sweeney Creek
Graveyard Cr
Cottonwood Cr
Porcupine Cr
Little Porcupine Cr
Rattlesnake Cr
Stellar Cr
East Bigsfoot Cr
Sand Cr
Muster Cr
Harris Cr
Custer Creek
Crooked Cr
Cherry Creek
Cedar Creek
Coal Cr
Cottonwood
Reservation Cr
Armells Cr
Pumpkin Creek

UNITED STATES
DEPARTMENT OF THE INTERIOR
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BUREAU OF RECLAMATION
FLOYD E. DOMINY, COMMISSIONER

MISSOURI RIVER BASIN PROJECT

YELLOWSTONE DIVISION

MONTANA – NORTH DAKOTA

(REGION 6)

MAP NO 290-604-104

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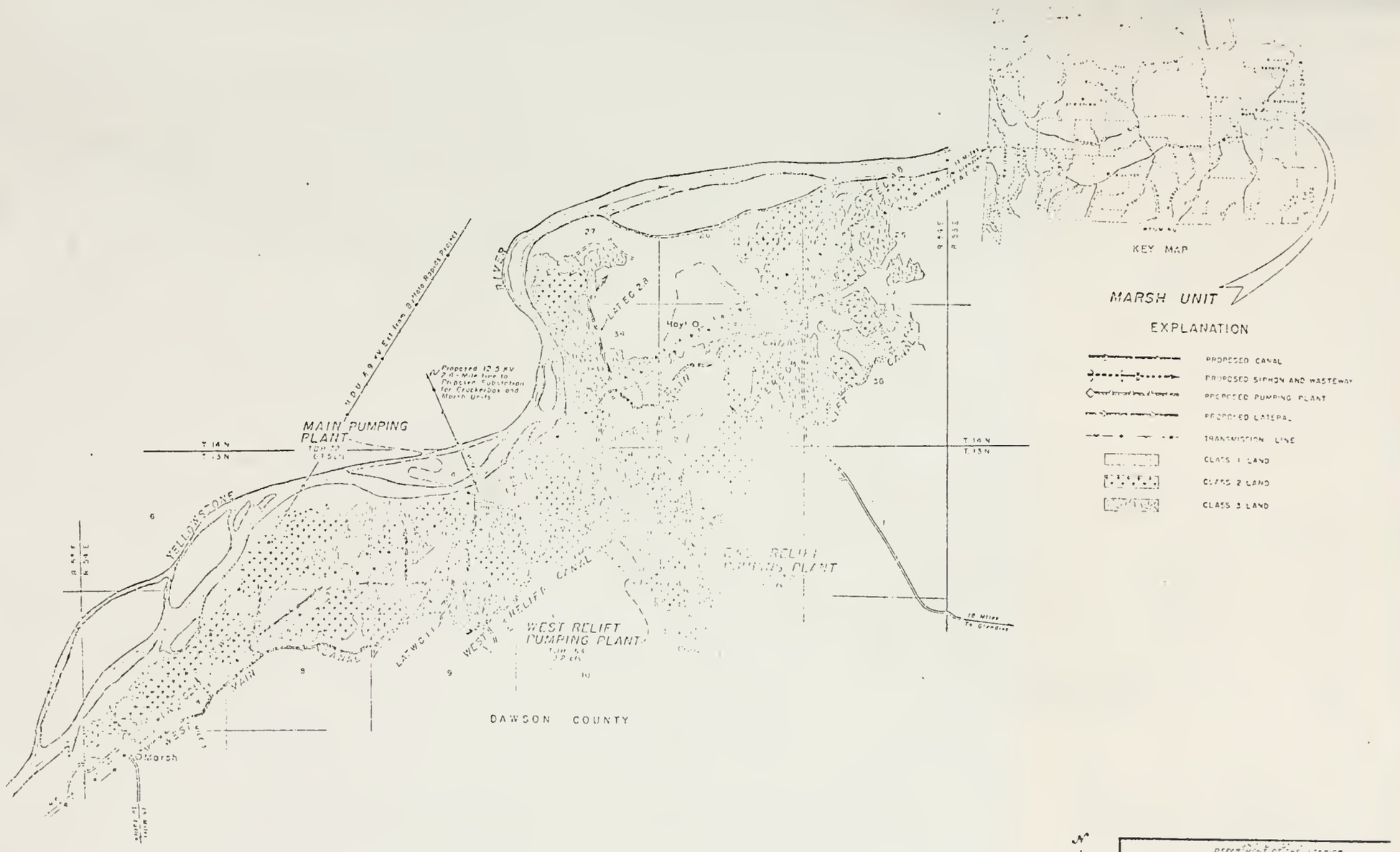
SCALE OF MILES

APRIL 1962

NOTE
Explanation shown on Map No 290-604-101



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YELLOWSTONE DIVISION, MONT.-N. DAK.

MARSH UNIT
GENERAL MAP

DRAWN J.A.S.
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CHECKED W.J.F.

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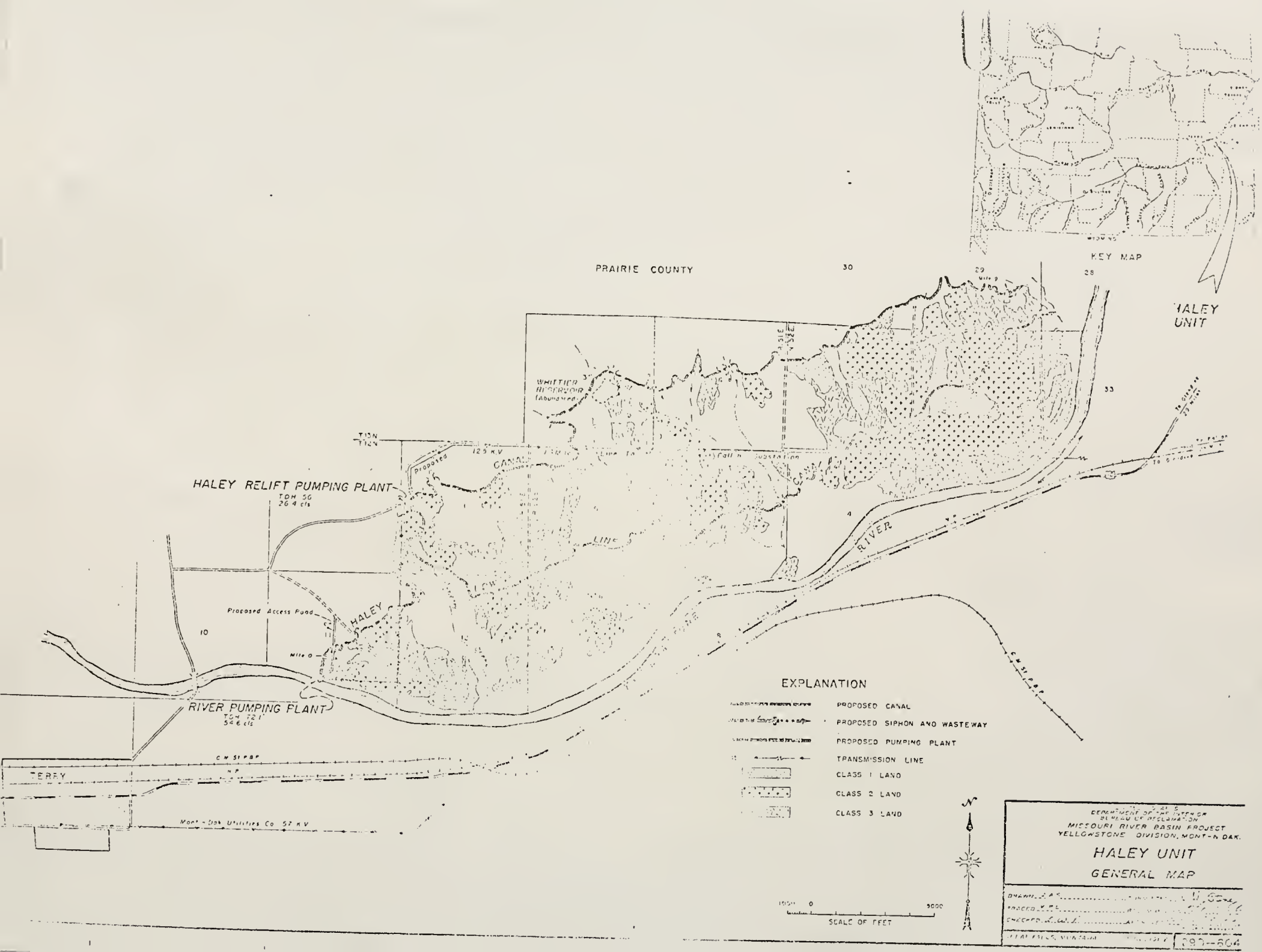
KEY MAP
HALEY UNIT
PRAIRIE COUNTY
WHITTIER RESERVOIR
HALEY RELIFT PUMPING PLANT
T30N R32E
26.4 cfs
Proposed Access Road
HALEY
RIVER PUMPING PLANT
T29N R31E
54.6 cfs
TERRY
Mont-Dak Utilities Co 57 K.V.
125 K.V.
Proposed
CANAL
LINE
RIVER
EXPLANATION
PROPOSED CANAL
PROPOSED SIPHON AND WASTEWAY
PROPOSED PUMPING PLANT
TRANSMISSION LINE
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
SCALE OF FEET
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION, MONT-N DAK.
HALEY UNIT
GENERAL MAP
DRAWN
TRACED
CHECKED
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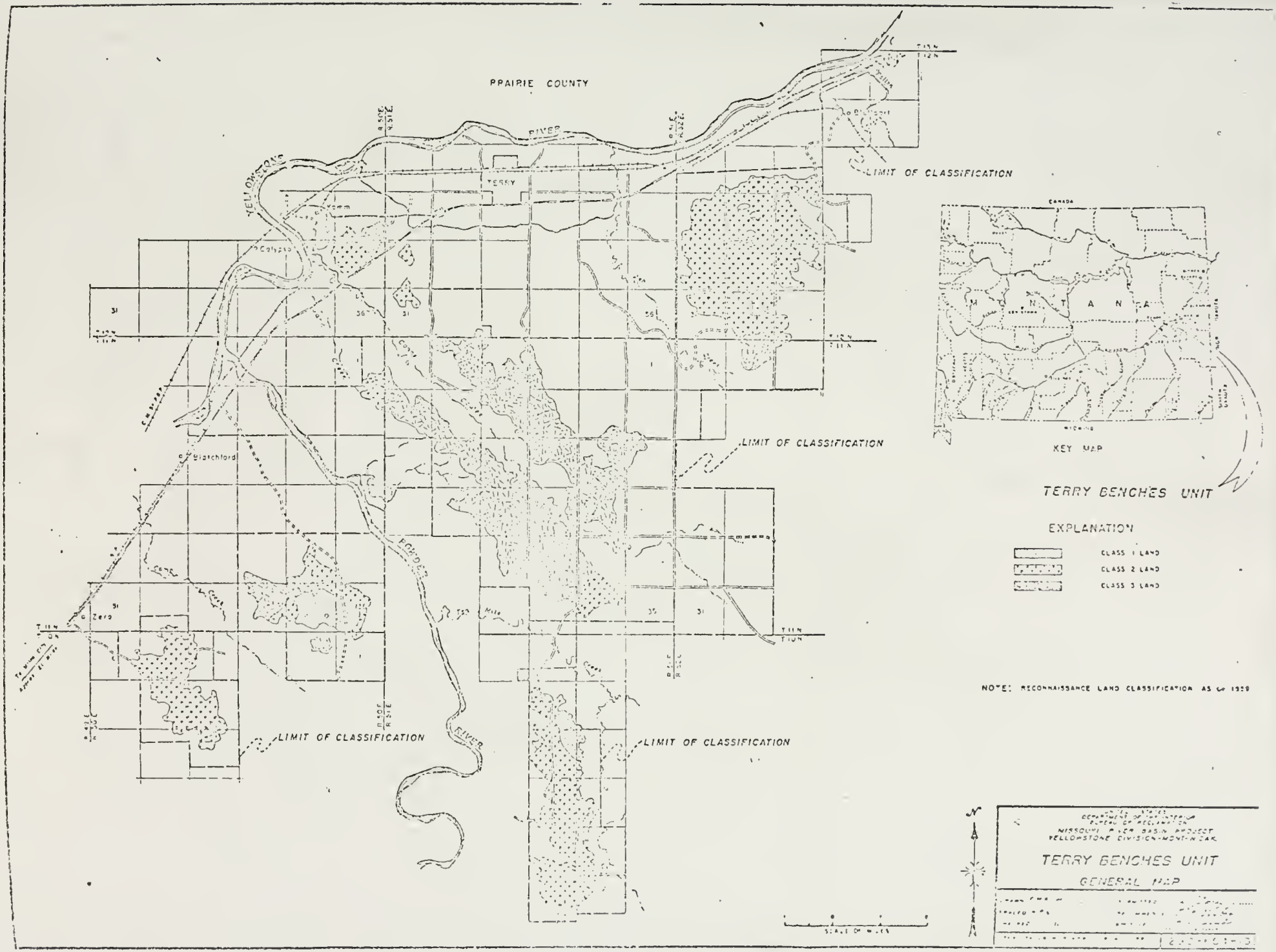
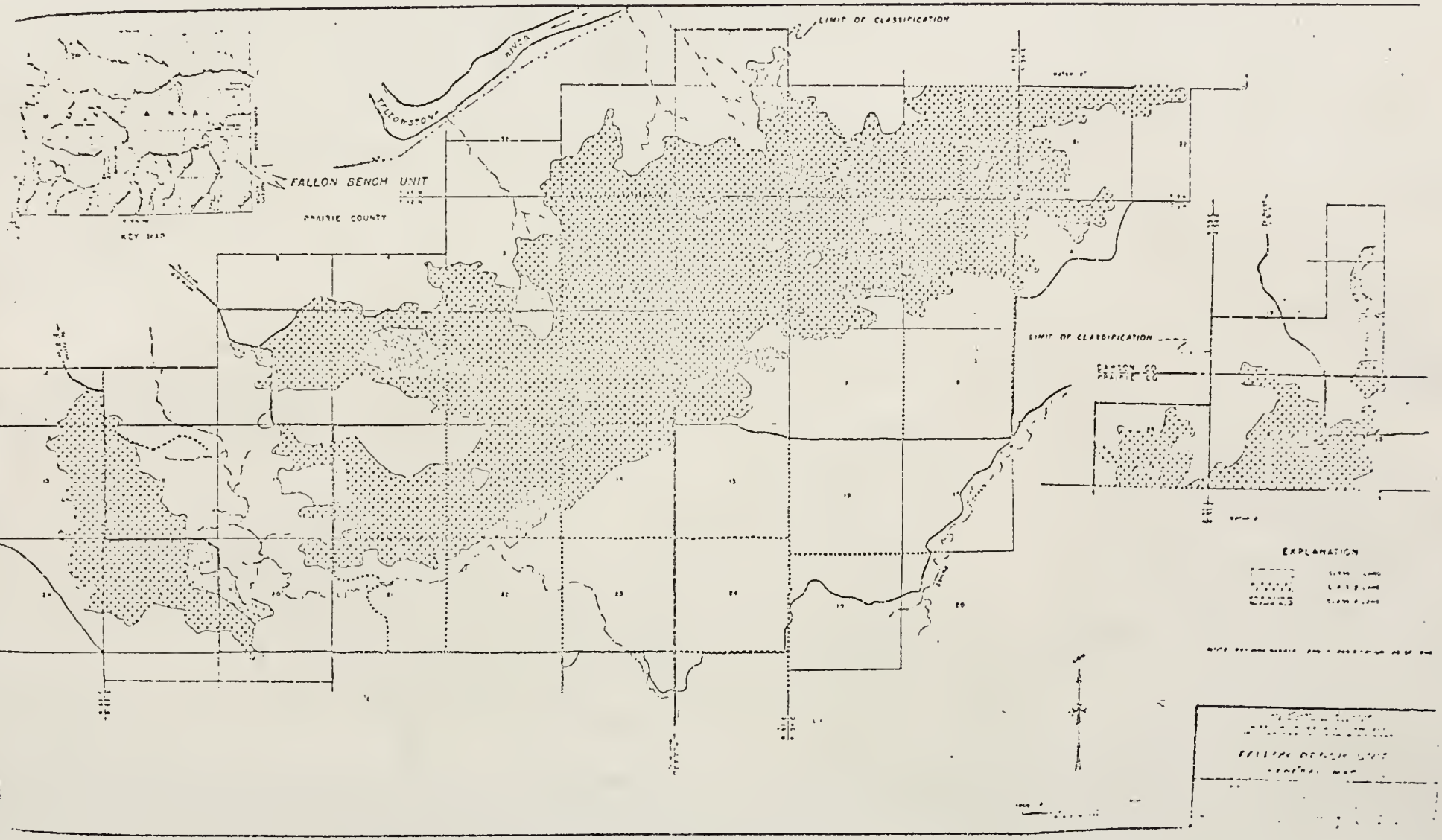
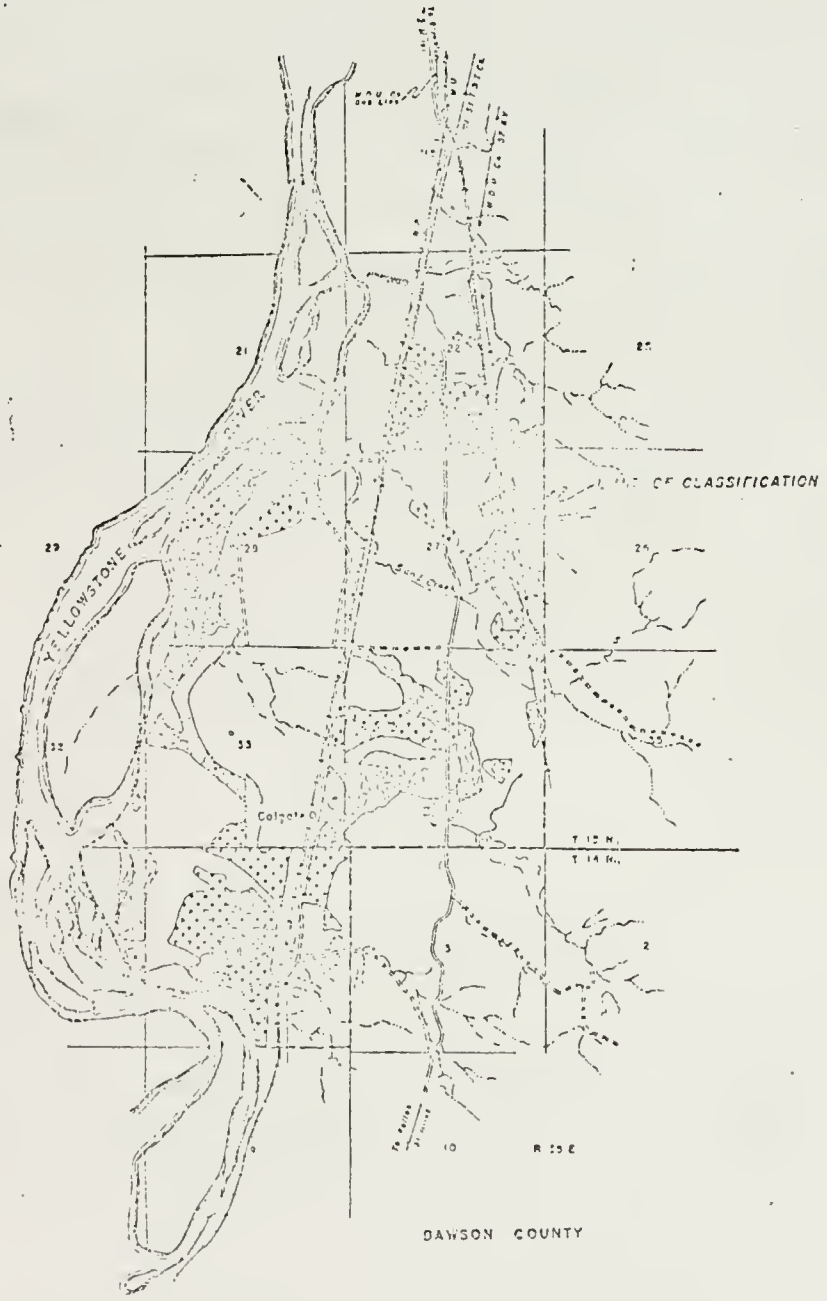
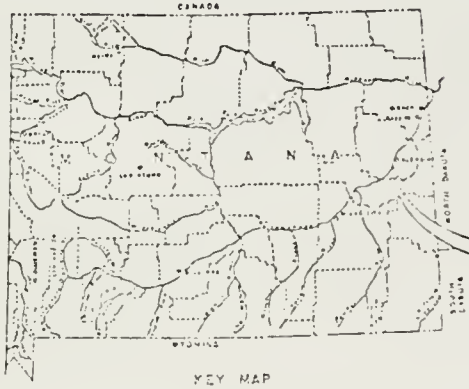

PRAIRIE COUNTY
YELLOWSTONE RIVER
TERRY
LIMIT OF CLASSIFICATION
LIMIT OF CLASSIFICATION
LIMIT OF CLASSIFICATION
LIMIT OF CLASSIFICATION
POWDER RIVER
Glendive
Glatchford
CANADA
MONTANA
KEY MAP
TERRY BENCHES UNIT
EXPLANATION
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
NOTE: RECONNAISSANCE LAND CLASSIFICATION AS OF 1929
SCALE OF MILES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION-MONT-N DAK.
TERRY BENCHES UNIT
GENERAL MAP

Figure 2


LIMIT OF CLASSIFICATION
YELLOWSTONE RIVER
FALLON BENCH UNIT
PRAIRIE COUNTY
KEY MAP
LIMIT OF CLASSIFICATION
EXPLANATION





KEY MAP

EXPLANATION

CLASS 1 LAND

CLASS 2 LAND

CLASS 3 LAND

NOTE: DETAILED LAND CLASSIFICATION AS OF 1950

1000 0 2000

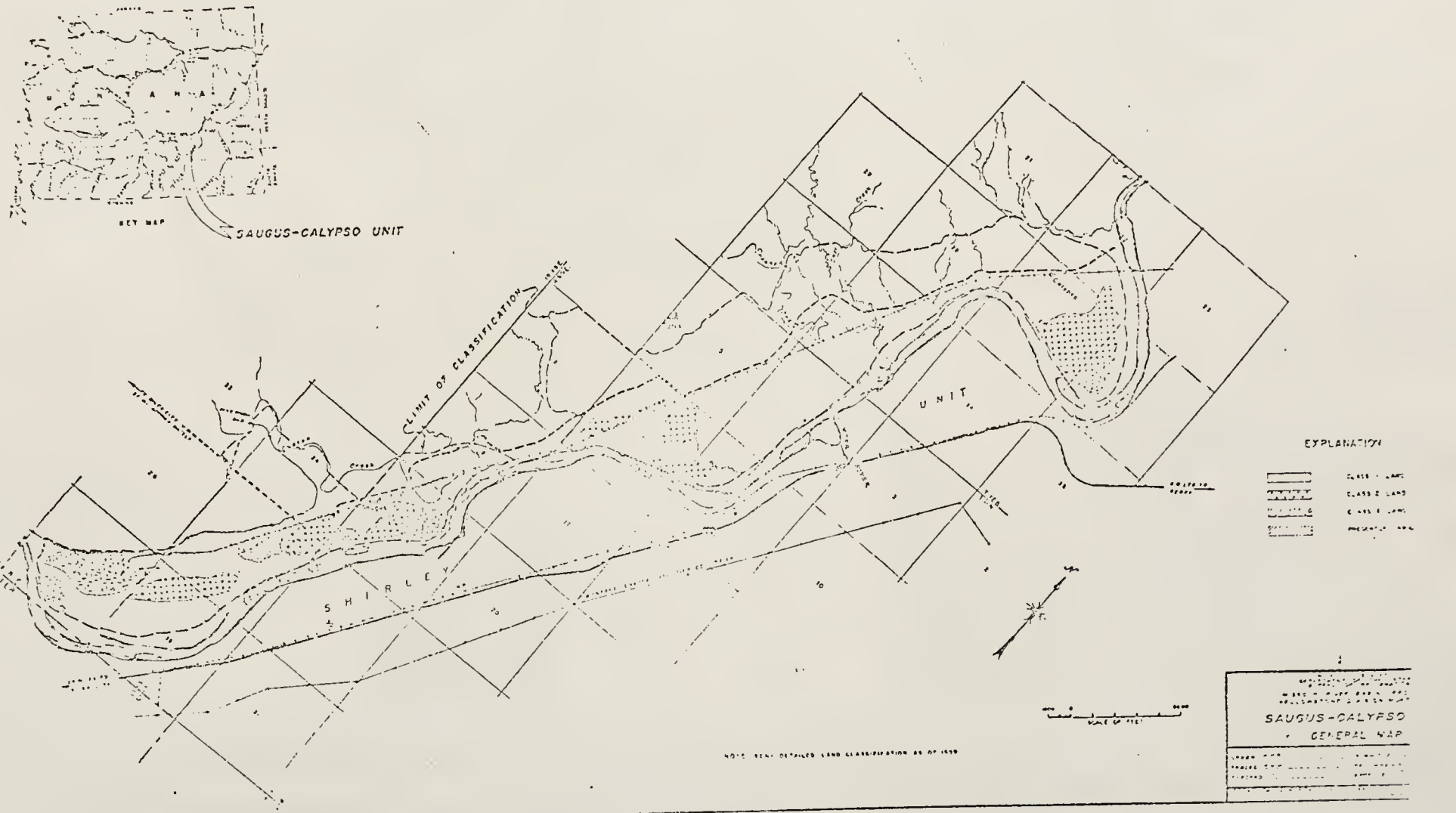
SCALE OF FEET

MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION, MONTANA

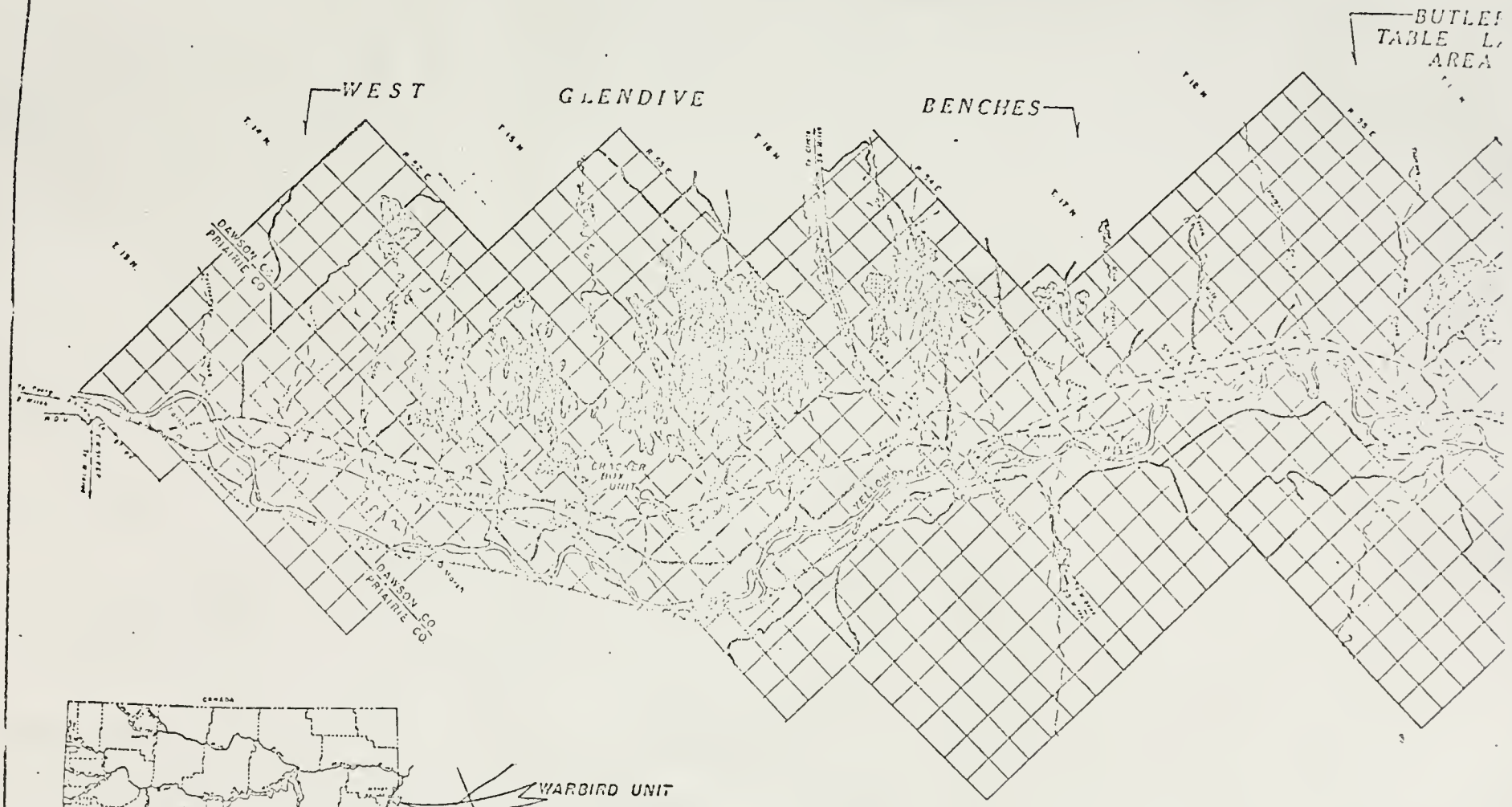
COLGATE UNIT

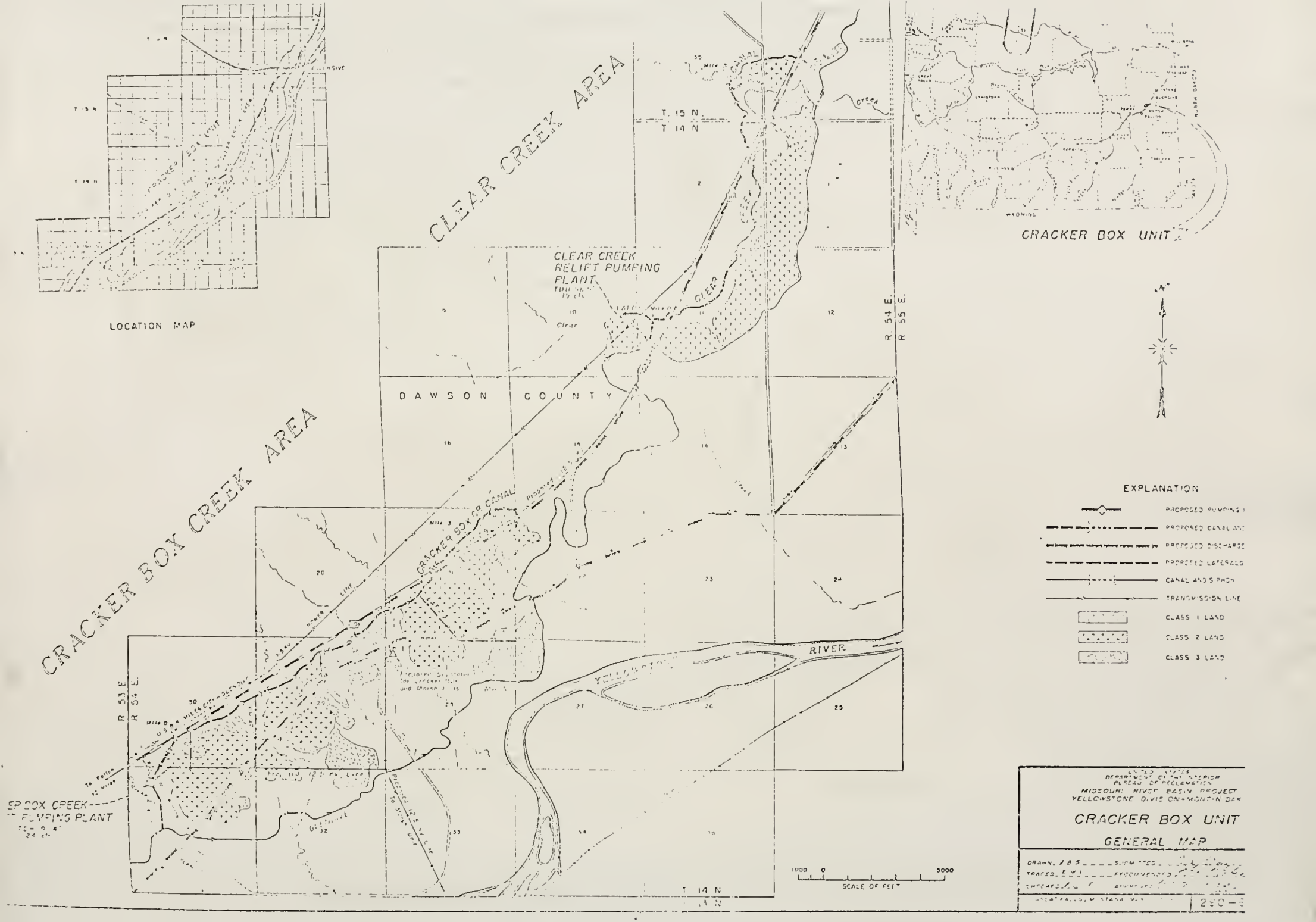
GENERAL MAP

Figure


KEY MAP
SAUGUS-CALYPSO UNIT
LIMIT OF CLASSIFICATION
UNIT
SHIRLEY
EXPLANATION
SAUGUS-CALYPSO
GENERAL MAP

Figur


BUTLER
TABLE L
AREA
WEST
GLENDIVE
BENCHES
DAWSON CO
PRAIRIE CO
CHICKEN BOX UNIT
YELLOWSTONE
WARBIRD UNIT
EXPLANATION
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
KEY MAP
NOTE: RECONNAISSANCE LAND CLASSIFICATION AS OF 1959
SCALE OF MILES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION-MONTANA
WARBIRD UNIT
GENERAL MAP


LOCATION MAP
CRACKER BOX UNIT
CLEAR CREEK AREA
CRACKER BOX CREEK AREA
CLEAR CREEK RELIFT PUMPING PLANT
DAWSON COUNTY
T. 15 N.
T. 14 N.
R. 53 E.
R. 54 E.
R. 55 E.
CRACKER BOX CR. CANAL
YELLOWSTONE RIVER
EXPLANATION
PROPOSED PUMPING PLANT
PROPOSED CANAL AND SIPHON
PROPOSED DISCHARGE PIPE LINE
PROPOSED LATERALS
CANAL AND SIPHON
TRANSMISSION LINE
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
1000 0 3000
SCALE OF FEET
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
YELLOWSTONE DIVISION-MONTANA DAK
CRACKER BOX UNIT
GENERAL MAP
DRAWN
TRACED
CHECKED
250-D

RELIFT PUMPING PLANT
STIPEK CANAL
DAWSON COUNTY
RIVER PUMPING PLANT
GLENDIVE
YELLOWSTONE RIVER
EXPLANATION
PROPOSED CANAL
PROPOSED SIPHON AND WASTEWAY
PROPOSED PUMPING PLANT
PROPOSED LATERAL
TRANSMISSION LINE
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
KEY MAP
STIPEK UNIT
SCALE OF FEET
MISSOURI RIVER B.S.N. PROJECT
YELLOWSTONE DIVISION-MONT-N DAK
STIPEK UNIT
GENERAL MAP

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7/13/76 Mary Carol B

Climate

Montana's climate is influenced by its interior continental position, movement and mixing of air masses and storms, northerly latitude, and mountain barriers producing orographic precipitation and lee-side rain shadow effects. The Yellowstone Basin extends from mountainous headwaters in south-central Montana through the dissected plains of southeastern Montana introducing considerable local variation in climate through altitudinal differences.

Precipitation through orographic lifting on windward slopes in the mountainous areas provide the basic flow in the Yellowstone and its tributaries. Moisture-laden North Pacific air provides sufficient snowfall through this mechanism in winter to assure reasonably dependable early summer runoff from mountain snowmelt. As a result of this moisture loss and because air warms and dries as it descends the eastern slopes and plains area, a rain shadow occurs over the larger dissected plains portion of the basin. During the summer, a semi-permanent thermal low pressure area over the southwestern U.S. induces unstable air to flow into Montana from the Gulf of Mexico resulting in frequent thunderstorms with occasional hail in eastern Montana. These storms are most common June through August. The average annual precipitation in the entire Yellowstone Basin is about 15 inches. Total annual precipitation exhibits a relatively large range, from over 70 inches in the Absaroke-Beartooth Mountains to less than 6 inches in the

immediate rain shadow along the Clarks Fork of the Yellowstone. The major portion of the basin in eastern Montana averages 13 inches annually. [1]

Distribution of rainfall shows a late spring maximum at all stations in the basin. In the plains portion of the basin this maximum may represent up to 70% of the total yearly precipitation, where in the west, this peak represents generally 35-50% of the total precipitation. This is due to greater maritime ~~moisture~~ influence in the western mountains in winter from storms originating over the Pacific Ocean. Eastern Montana, at the same time, is generally dominated by cold, dry and stable polar air penetrating the continental interior in winter resulting in very little winter precipitation. The Rocky Mountain chain provides a major physiographic barrier dividing the relatively warm, unstable Pacific air from the colder air occupying the eastern portion of the state. Displacement east or west of this air mass boundary in winter results in a chinook for eastern Montana or a cold spell for western Montana and the Columbia Basin.

Average monthly temperatures for January and July, the warmest and coldest months, reflect length of day, cloudiness, latitudinal and altitudinal temperature gradients, and proximity to oceanic influence. Length of day varies from about 9 hours of sunshine in winter to 15 hours in summer, greatly increasing daily solar heating potential. Cloudiness tends to moderate very cold or very warm temperatures. Latitudinal temperature gradients tend to be more pronounced in winter because of combination effects of low solar angles (less effective in heating)

1 USDA, SCS, Wind-Bighorn-Clarks Fork River Basins Type IV Survey Montana supplement, 1974.

and shorter daylight hours. In summer, day length increases northward, compensating effects of lower solar angles, thereby minimizing north-south temperature differences. Altitude generally varies inversely with temperature, so temperature would normally increase easterly in the Yellowstone Basin. Oceanic influence tends to moderate temperature extremes. This means that proximity to the Pacific Ocean creates a west to east temperature decrease in winter and a west to east temperature increase in summer. This counterbalances the altitudinal trend in winter and accentuates the same trend in summer.

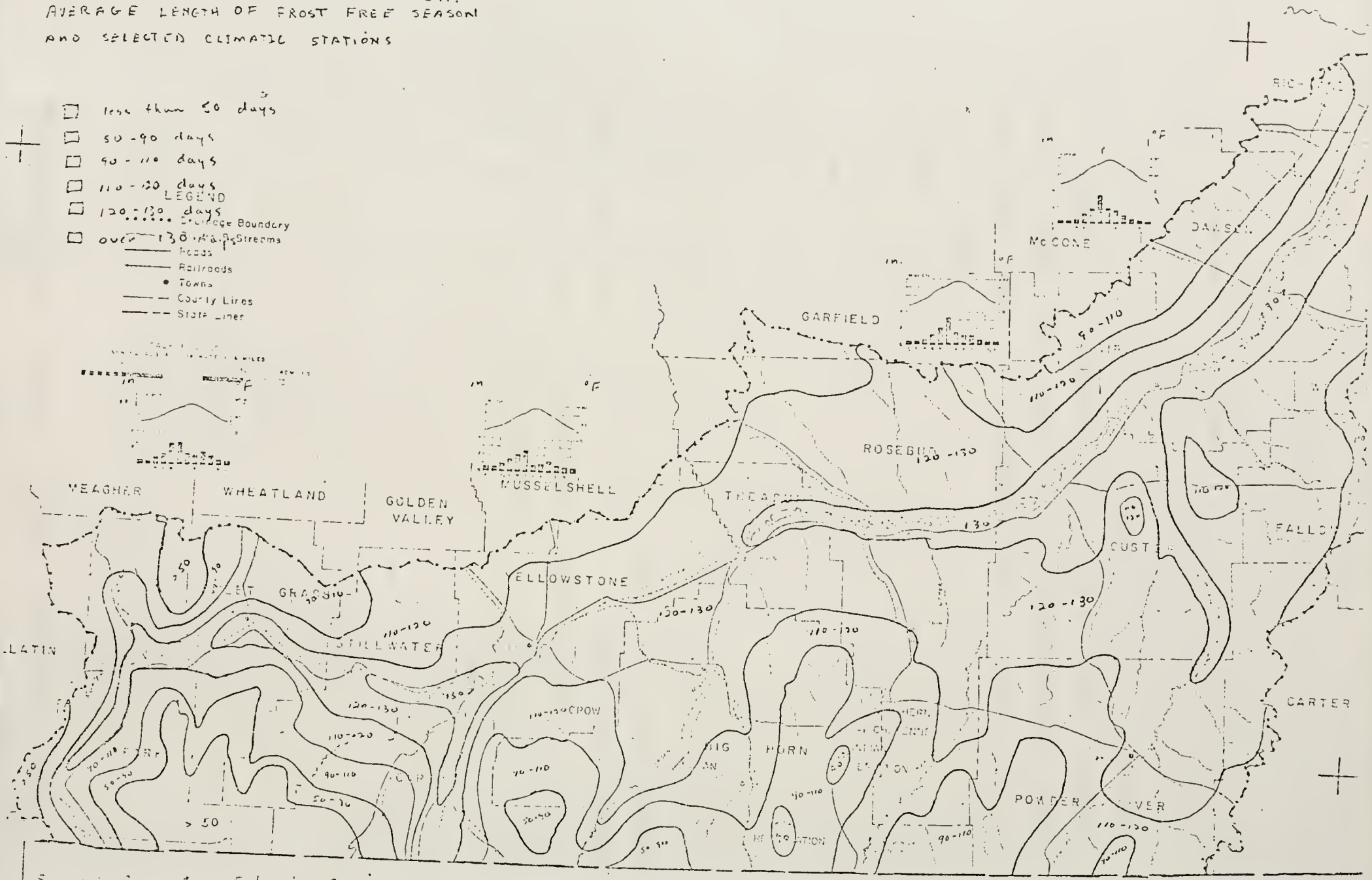
Average* July temperatures range from over 72°F in portions of the basin near the North Dakota state line to less than 56°F in the Absaroka-Beartooth mountains. Maximum-minimum temperatures in the warmest zone may range from over 100°F to about 40°F and from 75°-80°F to 25°F in the mountains. January temperature averages vary differently than July temperatures in the basin. Increasing continentality to the east and elevation to the west produce the coldest average temperatures of 12°-16°F. The south-central portion of the basin around Billings is warmest (20°-24° F.) due to some maritime influence, coupled with lower elevation and southerly latitude advantages.

Most of the arable land falls within a zone with about four months frost-free season. Extended length of day and maximum precipitation in early summer combine during this time to allow many crops to be grown in Montana that would not normally grow in a semi-arid climate or in a four-month freeze-free season.

* Average monthly temp = $\frac{1}{\text{days in month}}$[(daily minimum + daily maximum)/2]

YELLOWSTONE DRAINAGE BASIN

AVERAGE LENGTH OF FROST FREE SEASON AND SELECTED CLIMATIC STATIONS



Source: Cooperative Extension Service, Montana State University
AVERAGE LENGTH OF FROST FREE SEASON, by J.M. Caprio
March 1965

Air Quality

Air Pollution Potential

Air pollution potential is related to meteorological variables of wind, atmospheric stability and mixing depth. Wind acts as a direct dispersal agent, removing airborne pollutants from the source and diluting pollutants with surrounding air by turbulant action. Generally, high winds are conducive to dilution and dispersal and calm conditions are not. Atmospheric stability is related to existing vertical temperature gradients in the atmosphere. Stable conditions, such as those accuring during a ground-level temperature inversion, tend to concentrate pollutants near the surface and minimize dispersal.

Studies conducted by Super (1973) at Colstrip concluded that;

1. Ground level inversions or isothermal layers are extremely common. (99% of 169 mornings sampled).
2. Calm winds might be expected 3% of the time annually; average seasonal and annual winds 307 and 1053 feet above ground level exceeded 10 miles per hour.
3. Fumigation, or high ground level pollution brought about by mixing of emissions within a stable ground-contact layer of air might be expected 40% of the time during early morning hours.

Although the Colstrip situation is unique, similarity between atmospheric conditions persisting at Colstrip and

---

Super, A., Data collected for assessing air pollution potential at Colstrip by the Dept. of Earth Seiences, MSU, Bozeman. (1973)

many other stations in the Yellowstone basin suggest the conclusions drawn by Super (1973) might have wider application. Extention of these conclusions would dictate moderate to high air pollution potential during early morning hours on most days and persisting longer in winter than summer (deeper inversions in winter).

Air Quality

Only crude estimates of ambient air quality in the Yellowstone Basin are possible at this time due to a small number of monitoring stations. Data on total suspended particulates (TSP) is most complete. Monitoring stations are located at Billings (4 stations), Laurel, Forsyth, Miles City (2), Glendive and Sidney. In addition, rural monitors for TSP are located near Colstrip (2), Poplar, Lindsay (2), Fort Peck, Broadus, Scobey, Glendive, Ekalaka, and Lame Deer.

The background or ambient TSP can be estimated for Eastern Montana by examination of recent (1973, 1975-76) data for the rural stations listed above. This data ranges from a high of 29 micrograms per cubic meter (ug/m^3) at the rural Glendive station to a low of 6 ug/m^3 at Lame Deer. The mean (15.4) and standard deviation (7.0) provide a bracketed value estimating normally present TSP. By comparing values of background air quality (15.4 ± 7.0) to values obtained in urban or industrialized environments, some measure of the degree of air quality reduction attributed to urban-industrial sources can be derived. This has been done for TSP for urban monitors in the Yellowstone basin. (Table ___).

TABLE____

City	Actual Annual TSP[1]	-Background[2]	=Urban-Industrial Contribution[2]
Laurel	33	15	18
Billings	50*	15	35
Forsyth	36	15	21
Miles City	54**	15	39
Glendive	31	15	16
Sidney	26	15	11

1. All values are average annual geometric means measured in ug/m^3. The state standard (maximum allowable) is 75 ug/m^3.

2. These values should be considered mean values that may vary accordingly to local background air quality. One standard deviation variance would include values within ± 7 ug/m^2 of each value.
   * Mean of four monitors having mean annual values of 40, 30, 68, and 61 ug/m^3
   ** Mean of two monitors having mean annual values of 22 and 85 ug/m^3.

Source: Air Quality Bureau, Department of Health and Environmental Sciences.

In addition to TSP, carbon monoxide (CO) hydrocarbons (HC), oxides of nitrogen (NO_2), sulfur dioxide (SO_2), and total flourides (F) are monitored in the urban-industrial locations above. In table ___, quantitative data are expressed as a fraction showing actual values over the appropriate allowable standard. Qualitative remarks are 'best guess' estimates supplied by the Air Quality Bureau.[1]

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1. David Maughan, Air Quality Bureau, DHES

TABLE _____.

City	CO	HC	NO_2	SO_2	F
Laurel	Nil	exceeds standard	Nil	*.31/.25 (1 hr. max) .2/.5(3hr.) .08/.14 (24 hr.)	high
Billings	2.5/35 (average) 26.5/35 (max. 1 hr) *13.1/9 (max. 8 hr)	*1.29/.24 6-9 a.m.	.039(max.) .05	.15/.25 (1 hr. max)	Moderate
Forsyth	Nil	Nil	Nil	Nil	Nil
Miles City	Low	Nil	Nil	Nil	Nil
Glendive	Nil	Nil	Nil	Nil	Nil
Sidney	Nil	Nil	Nil	Nil	Low

* Exceeds standard
Standards are those adopted May 7, 1967 by the Clean Air Act of Montana Section 69-3909, Subsection 12.

Automobiles and petroleum refining generally are the major contributors to carbon monoxide and hydrocarbon levels respectively. Sulphur dioxide is normally the result of thermoelectric generation. Problems exist in the Laurel - Billings area as a consequence of the abundance of these activities in the proximity. With the exception of the standard violations in the above table, pollutant levels in cities of the Yellowstone basin are generally moderate to low in comparison

to existing state air quality standards.

Perhaps the most significant standards related to potential use of Yellowstone water for industrial development are the Environmental Protection Agency standards for prevention of significant deterioration (PSD). Stndards in effect for Montana would allow a maximum average annual increase of 10 ug/m^3 for TSP and 15 ug/m^3 for SO_2 above 1974 recorded ambient levels. This means that significant deterioration would occur at pollution levels well below the allowable maximum under the Clean Air Act of Montana and will eventually limit the localized growth of industries producing particulates and SO_2.

Physiography:

The Yellowstone basin in Montana is contained within three major physiographic subdivisions or provinces defined by Fenneman (1931). These are the Northern Rocky Mountains, Middle Rocky Mountains, and the Great Plains Provinces. The majority of the area lies in the unglaciated portion of the Missouri Plateau and the Powder River basin subprovinces of the Great Plains Province.

The Missouri Plateau is a large dissected upland ranging in elevation from about 2000 feet near the Montana-North Dakota boundary to between 5000-6000 feet near the western boundary with the Rocky Mountains. Generally, nearly flat lying beds of shale and sandstone are present which, near major rivers, are dissolved into 'breaks' or more intricate 'badland' topography. The Powder River Basin is a broad structural basin (not the drainage basin of the Powder River) occupying the area between the Black Hills and the Bighorn Mountains. It grades indistinguishably into the Missouri Plateau just south of the main stem of the Yellowstone River between Hysham and Miles City. The landscape in the two subprovinces is dominated by plains and low-lying hills and tablelands with a few isolated uplands, buttes and mesas.

The Bighorn Mountains, a major range of the Middle Rocky Mountain province extends northwestward into Montana from Wyoming. Elevations range from around 5000 feet in the foothills facing the Powder River basin to nearly 8000 feet in the Montana portion of the range. The Bighorn River cuts northeasterly through the range and Bighorn Lake behind Yellowtail Dam fills the gorge. The Pryor Mountains are a small detached uplift which can be physiographically considered a northward continuation of the Bighorn Mountains. Elevations in the Pryors range from 5000 feet to nearly 9000 feet. Geo-

logically the Bighorn Mountains contain a core of intrusive crystalline rock flanked by steeply dipping sedimentary rocks. The Pryor Mountains are a series of overthrust fault blocks exposing some of the oldest sedimentary rocks in the Yellowstone basin.

The Beartooth-Absaroka Mountains are the northernmost extention of the Middle Rocky Mountains. Elevations range to over 12,500 feet and most of the area was glaciated several times during the Pleistocene Ice Age. Ancient pre-Cambrian igneous and metamorphic rocks form the core of the uplift with progressively younger sedimentary rocks exposed outward from the precambrian complex. In addition, Tertiary volcanics (lava and related rocks) and intrusive (granitic) rocks are extensive in this area.

A portion of the western watershed boundary is included in the northern Rocky Mountain physiographic province. The Gallatin and Bridger Ranges and the Crazy Mountains northwest of Big Timber are in this province. The reason for this physiographic separation is due more to structural than to lithologic differences. The Northern Rocky Mountains have generally had a more complex geological history than the rest of the Rocky Mountain chain, with involved sequences of uplift, faulting, folding, volcanic activity, and erosional history.

Land forms are varied due to study area encompassing several different physiographic provinces, each of which imposes different structural and lithological constraints on resultant landforms. A complete inventory is not feasible herein, however, some generalizations about land-forms based on specific quantifiable parameters are possible. Figure _____ shows classes of land-surface form in the Yellowstone basin modified from Hammonds (1964) map covering the United States. The measurable parameters are percentage of flat to gently sloping land (less than 8%) and local relief, or the maximum elevational difference between ridges and valleys

in a small area.

Geology:

Structure.

Three general structural features related to the Tertiary Laramide Orogeny are present in the study area; broad anticlinal folds and domes; broad structural basins or synclines; and mountain uplifts, often associated with igneous intrusions, folding, and faulting.

Anticlinal upwarpings are present in the Cedar Creek Anticline, Porcupine Dome, and the Black Hills Uplift. The Cedar Creek Anticline has a NW-SE axis plunging near Glendive and brodening narrowly to the southeast. The Porcupine Dome is centered north of Forsyth and is probably directly related to an igneous intrusion (Thom, 1923). The Black Hill Uplift is a domal structure centered in western South Dakota, however, structural deformation extends into the study area in southeastern Montana. Erosional exposure of these folds has uncovered Cretaceous sediments (upper Mesozoic shales and sandstones mostly) from the cover of the extensive, Tertiary, Fort Union Formation. These upper Cretaceous sediments, known collectively as the Montana Group, are not distinguished seperately from other Mesozoic sediments on the geologic map (Figure ____) but cover the majority of area of exposed Mesozoic rocks.

Synclinal folds and flat-lying sediments occupy the area between uplifts. The Powder River basin, discussed earlier, occupies a large area south of Forsyth and extending into Wyoming. The Montana extention of this syncline is known as the Bull Mountain syncline. The other major syncline in the Yellowstone basin is the NNW trending Reed Point syncline between the mountain uplifts forming the Beartooth Plateau to the west and the Pryor Mountains to the east.

Generally the coal-bearing, Tertiary, Fort Union formation is exposed at the surface in synclines and flat lying sediments.

Major mountain uplifts in the study area include the Bighorn-Pryor uplift, the Beartooth-Absaroka uplift, Orogeny of the of the Gallatin and Bridger Ranger, and the Crazy Mountains igneous intrusion. These major uplifts have been distinguished from anticlinal folds because erosional relief is generally greater, faulting is normally present, and generally older sedimentary or intrusive rocks are exposed near the axis of uplift. These core rocks may range from early precambrian (about 1.8 billion years before present) igneous and metamorphic rocks to Paleozoic sedimentaries (250-600 million b.p.) to relatively recent tertiary granites (65-75 million b.p.). Normal or tensional faulting is present in all uplifts and some reverse or compressional faulting is also present in the Pryor-Bighorn uplift. Lineated fault clusters, most notably the Lake Basin-Huntley lineament have resulted from movements along fractures between large scale crustal plates in western North America.

Stratigraphy

The oldest rocks mapped are precambrian (greater than 600 m.y.). The only significant exposures of these rocks are in the Beartooth Plateau, where granite, shist, and gneiss form the 'basement complex'*, ~~and~~ the ultra-mafic** Stillwater complex bordering the Beartooth plateau to the north.

** ultra-mafic means that dark minerals (biotite, hornblende, amphibole) predominate over light or felsic minerals (quartz, feldspar, muscovite) in the basic composition of the rock.

* 'basement complex' means simply that these rocks are normally found at the bottom of any exposed, drilled, or excavated stratigraphic sequence.

Paleozoic rocks rest unconformably on the preCambrian outcrops and are generally exposed in the study area along the margins of the Absaroka-Beartooth uplift and in the center of the Bighorn-Pryor uplift. Perhaps most visually significant in this sequence covering the time from 250 m.y. to 600 m.y. are the thick, cliff-forming, carbonate sequences. These include the Bighorn Dolomite (Ordivician) and the Jefferson, Madison and Quadrant formations of Mississippian Age.

Mesozoic formations deposited from 250 m.y. to about 100 m.y. before the present ~~one~~ are rare until Cretaceous (upper Mesozoic) times. Cretaceous sediments include the Kootenai Group and Colorado shale overlain by the Montana Group, a complex group of sandstones, shales, siltstones, and mudstones. The Montana Group straddles the Cretaceous-Tertiary boundary and includes the Livingston formation (weathered sediments from the Elkhorn volcanic source, McMannis 1955), and the Tertiary Fort Union formation.

Cretaceous-Tertiary intrusive activity associated with the Larimide Orogeny* formed granitic cores to several areas in the Beartooth-Absarokas and the Crazy Mountains. Associated volcanic activity extruded lava over extensive areas south of Livingston and Big Timber.

Quaternary or recent deposits include floodplain alluvium along the Yellowstone and tributaries as well as numerous terrace systems of alluvial origin. Terraces are best developed along the main stem of the Yellowstone, the Beartooth mountain front, and the Bighorn River below Yellowtail dam.

* orogeny means a mountain building phase of geologic history

Ecomonic Geology

Resources derived from geologic formations fall into three categories: metallic, non-metallic, and fuel.

Metallic ore deposits are limited in the study area to the igneous and metamorphic rocks of the 'basement complex' and the Stillwater Complex in the Beartooth-Absaroka Mountains and Cretaceous-Tertiary age granitic intrusives in this area and in the Crazy Mountains. Granitic intrusions normally inject (under pressure metallic ores) into pre-existing host rock as veins of concentrated material separated while the molten intrusion is cooling. The Stillwater Complex has active mines and continuing exploration. It contains one of the worlds richest collection of minerals--chromium, copper, nickel, platinum, palladium, silver, gold, and iron.

Non-metallic resources are derived from sedimentary deposits. These include limestone, gypsum, clay (bentonite and kaolinite), phosphate, silica, and building stone from Tertiary and older deposits, ~~and~~ Sand and gravel from Quaternary terrace deposits.

Oil and gas are confined to sedimentary rocks of the central and eastern portion of the study area, where structural traps concentrate these fossil fuels. The Cedar Creek anticline southeast of Glendive is a major field with smaller fields occurring west of Sidney, and south of Hardin and Miles City.

Coal is present in several Mesozoic and Tertiary sedimentary formations, but by far the most extensive, thickest, and economically useful coal is in the Tertiary Fort Union formation. Within this formation, the grade of coal changes progressively from lignite in northeastern Montana, to subbituminous in the Powder River basin, to bituminous in the Red Lodge coal field southeast of Livingston (Perry 1962). Present interest in coal-gasification of lignite and mine-mouth electrical generation plants within the Yellowstone basin may contribute to future demands for water from the Yellowstone or its tributaries.

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YELLOWSTONE DRAINAGE BASIN
L. FORM MAP

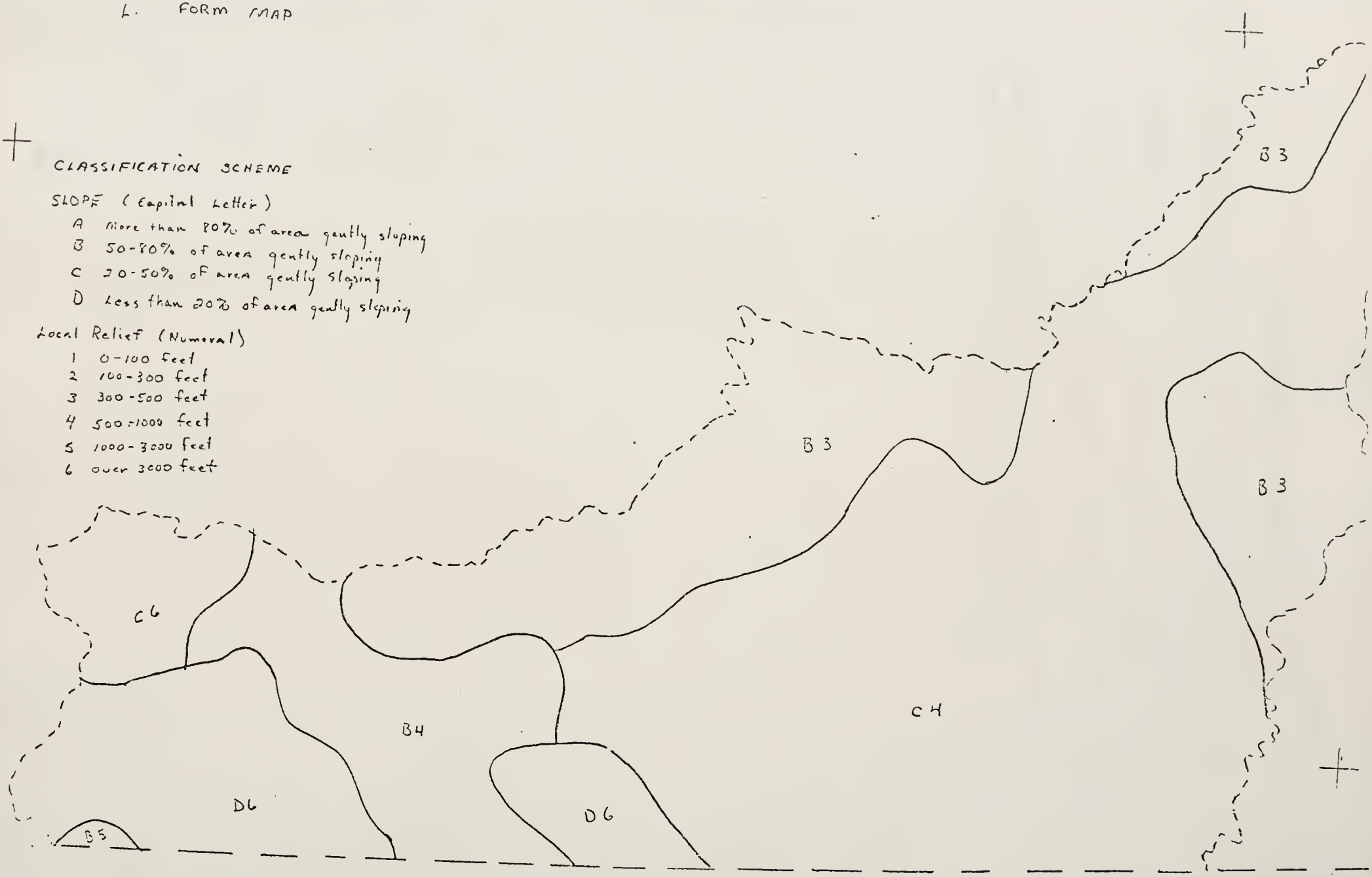
CLASSIFICATION SCHEME

SLOPE (Capital Letter)

- A More than 80% of area gently sloping
- B 50-80% of area gently sloping
- C 20-50% of area gently sloping
- D Less than 20% of area gently sloping

Local Relief (Numeral)

1. 0-100 feet
2. 100-300 feet
3. 300-500 feet
4. 500-1000 feet
5. 1000-3000 feet
6. over 3000 feet



adapted from Edwin H. Hammond, "Classes of land surface form in the forty-eight States, U.S.A.", Annals, Assoc. of Amer. Geographers, Vol. 54, No. 1, 1964, map supplement No 4, 1:5,000,000.

ROUGH DRAFT

Vegetation

Vegetation assemblages within the study area result from interactions over time between topography, soils, and climate, ~~over time~~. In addition, existing vegetation represents the product of disruption and adaptation through natural (fires, drought, wildlife grazing) and man-caused (domestic grazing, agriculture, urban sprawl, pollution) disturbance. Because existing vegetative assemblages are transient features that may change rapidly with changing environmental constraints, an adequate and up-to-date inventory of vegetation is not possible for an area the size of the Yellowstone basin.

The vegetation map (Figure_____) shows predominant species distribution for natural vegetation. This map depicts only natural vegetation on the assumption it is a valid indicator of land productivity. Grazing, farming, and other land uses may have recently altered or eliminated natural vegetation species in certain areas depicted on this map.

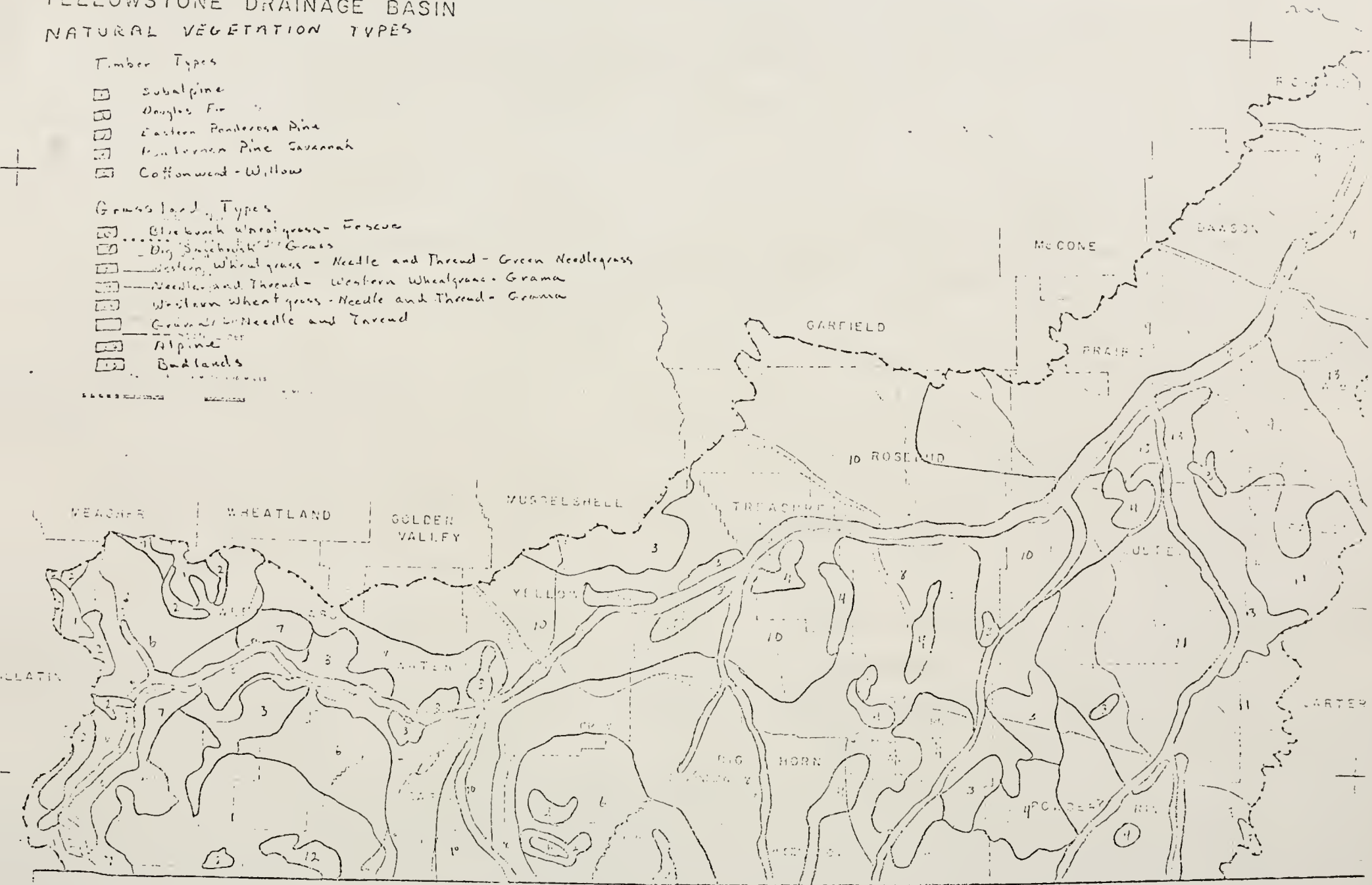
There are 13 vegetation types in the study area, classified according to dominant (and in some cases major subdominant) life forms. Environmental associations for the timber and grassland vegetation types are shown in tables _____ and_____. Rainfall, related to elevation, is a major constraint in delineating between grasslands and timber vegetation. Grasslands (with the exception of alpine grassland) generally occur where precipitation is less than 14 inches annually. Ponderosa pine savannah occurs when precipitation is slightly above 14 inches and timber/grassland ratios increase rapidly with increasing precipitation.

AND ENVIRONMENT & ASSOCIATIONS

VEGETATION TYPE	No. 1 Subalpine	No. 2 Douglas Fir	No. 3 Eastern Ponderosa Pine	No. 4 Ponderosa Pine Savanna	No. 5 Cottonwood-Willow
Principal Associated Species Trees	Subalpine fir Lodgepole pine Engelmann spruce Douglas fir Mountain hemlock Whitebark pine	Ponderosa pine Lodgepole pine Western larch Limber pine Engelmann spruce Subalpine fir	Rocky Mountain juniper Horizontal juniper	Rocky Mountain Juniper	
Shrubs	Grouse whortleberry Big whortleberry Devil's club Red mountain heath Menziesia	Ninebark Oregon grape Fringed sage Snowberry Big sagebrush Dwarf huckleberry	Skunkbush sumac Western snowberry	Western snowberry Skunkbush sumac	Rose Buffaloberry Snowberry Chokecherry Serviceberry
Grasses & grasslike	Idaho fescue Bentgrass Brucegrass Elk sedge	Rough fescue Pine Reedgrass Bluebunch wheatgrass Idaho fescue Elk Sedge	Bluebunch wheatgrass Needle and thread Blue grama Western wheatgrass	Bluebunch wheatgrass Western wheatgrass Blue grama Native bluegrass	Sedges Wirerush
Forbs	Aster Bluebell Lupine Beargrass	Beargrass Arrowleaf balsamroot Arnica False Solomon's seal	Phlox Arrowleaf balsamroot	Phlox Lupine	Lambsquarter goosefoot Stickweed
Geographical Area(s)	western & central Montana	central & western Montana	eastern Montana	eastern Montana	central Montana
Topography	rough; mountains	mountainous	rough broken land along the Missouri and Yellowstone rivers and rocky hills rising from plains	rolling to hilly on breaks to terraces	bottomland, river and creek bottoms
Elevation (ft) (Mean Sea Level)	5,500 - 9,500	3,000 - 7,900'	3,000 - 4,500'	3,300 - 4,000'	3,100 - 6,000'
Exposure	northerly but variable	northerly to southerly	variable; denser stands on north and easterly	southerly ridgetops and swales	variable
Precipitation Zone (annual)	20-30" +	20 - 30"	10-18"	12 - 14"	14-20"
Soils	sandy loams to rocky	sandy loams to clays; best on porous loams; deep rich well drained	rocky and gravelly, and poorly developed	stony, or gravelly to loams and alluvium	gravelly, sandy, rich humus, some clay soils
Major Resource Uses	~~Continental Divide~~ watershed timber wildlife recreation range	~~Continental Divide~~ timber recreation wildlife watershed range	range watershed wildlife recreation	watershed range wildlife	streambank stabilization, wildlife
Remarks	revegetation problems occur in that portion having a whitebark pine subtype which is from above 7,000 [illegible] the divide and [illegible] above 7,500 ft. east [illegible] but maybe [illegible]				severe

VEGETATION TYPE	No. 6 Bluebunch Wheatgrass-Fescue	No. 7 Big Sagebrush-Grass	No. 8 Western Wheatgrass-Needle & Thread-Green Needlegrass	No. 9 Needle & Thread-Western Wheatgrass-Grama	No. 10 Western Wheatgrass-Needle & Thread-Grama	No. 11 Grama-Needle & Thread	No. 12 Alpine	No. 13 Badlands
Principal Associated Species Trees	Limber pine Horizontal juniper							Rocky Mountain juniper Ponderosa pine
Shrubs	Shrubby cinquefoil Big sagebrush Fringed sage Skunkbush sumac	Rubber rabbitbrush Fringed sage Prickly pear Broom snakeweed	Fringed sage Big Sagebrush	Broom snakeweed Prickly pear	Big sagebrush Prickly pear Silver Sagebrush Fringed sage	Fringed sage	Snow willow Sitka alder willow Western bedum Red mountain heath	Green rabbitbrush Nuttall's saltbush Silver sagebrush Fringed sage Winterfat Big sagebrush
Grasses & grasslike	Western wheatgrass Prairie junegrass Threadleaf sedge Needle and thread Kentucky bluegrass Northern grama	Native bluegrass Prairie junegrass Blue grama Bluebunch wheatgrass Idaho fescue Grama mainly Needle and thread	Prairie junegrass Threadleaf sedge Canada bluegrass Blue grama Native bluegrass	Threadleaf sedge Native Bluegrass Prairie junegrass Plains reedgrass Bluebunch wheatgrass Needleleaf sedge	Native bluegrass Green needlegrass Prairie junegrass Plains reedgrass Plains muhly Threadleaf sedge	Native Bluegrass Prairie junegrass Bluebunch wheatgrass Needleleaf sedge Threadleaf sedge	Sheep fescue Timber oatgrass Bluegrass Alpine bluegrass Alpine timothy Sedge	Meadow segebrush Needle-and-thread Bluebunch wheatgrass Prairie junegrass Blue grama Threadleaf sedge Plains muhly Western wheatgrass Red three-awn
Forbs	Lupine Yarrow Wild onion Arrowleaf balsamroot	Pussytoes Phlox Locoweed Lupine	Yarrow Lupine Phlox Gilia-ness	Scarlet globemallow Curlycup gumweed Pricklypear	Sagebrush Wild buckwheat Scarlet globemallow	Phlox Lupine Gilia-ness	Lupine Bistort Alpine forget-me-not	Scarlet globemallow Western wallflower Phlox
Geographical Area(s)	western Montana & central Montana	eastern Montana & central Montana & western Montana	central Montana & eastern Montana	eastern Montana & central Montana	central & eastern Montana	eastern Montana	south central Montana	eastern Montana
Topography	[illegible] steep, short slopes of limber pine & rock outcrops to plains	foothills	gently sloping to rolling	rolling	plains to rolling and rough	gently sloping to rolling	rolling to very steep, above timberline	rough breaks
Elevation (ft) (MSL)	[illegible] Creek	3,150 - 4,350'	3,640 - 4,850'	3,050 - 5,200'	3,640 - 4,850'	3,000 - 4,200'	above 9,500'	3,640 - 5,640'
Exposure	Southeast—south & southwest slopes; Canyons—all & west slopes	south	variable	variable	variable	variable	variable	variable
Precipitation Zone (ann.)	16-20"	10-14"	16-20"	10-14"	10-14"	10-14"	above 30"	10-14"
Soils	Shallow; sandy to gravelly [illegible] loamy	shallow soils; clay loam	shales and where clay or clay loam in B horizon	"A" & "B" horizons; silty to sandy loams	shales and where there is clay or clay loam in B horizon; heavy soils, sandy to gravelly	variable; grama more prevalent on drier sites	shallow; coarse sandy) to loamy loam	shaly clay
Major Resource Uses	[illegible] wildlife recreation	watershed wildlife range	range cultivation (Cascade county)	range wildlife	range wildlife	range wildlife	recreation summer sheep range	wildlife limited range; recreation
Comments	With increased elevation the Festuca assume dominance and bluebunch is uncommon			blue grama increases with heavy grazing	fine sagebrush throughout in large quantities; blue grama increases with heavy grazing	blue grama increases with heavy grazing	very sensitive	very sensitive to disturbance; very sparse vegetation

YELLOWSTONE DRAINAGE BASIN
NATURAL VEGETATION TYPES



Source: Melvin S. Morris, Natural Vegetation of Montana (Map), School of Forestry University of Montana, 1964.
Northern Plains Resource Program, Major Ecosystems and Surface Rehabilitation

DRAFT

Yellowstone Basin Water Reservation EIS
Description of Soils

The Water Resources Division of the Montana Department of Natural Resources and Conservation has completed a land classification survey of the Yellowstone Basin. Land classification is the process by which soils, relief and climate are systematically appraised and lands are placed in categories based on similarity of characteristics. Land classification surveys made by the Water Resources Division are specifically designed to establish the degree of suitability of land for sustained irrigation farming. The term "irrigable land" as used in this reconnaissance classification, includes land with soils, topography, and drainage features that will support sustained irrigated agriculture with proper water management, drainage and other necessary conservation practices. Because technological advances in irrigation are taken into account, slope and surface topography become less important as rapid expansion of sprinkler irrigation takes place. The irrigable lands are divided into classes on the basis of their relative suitability for irrigation farming. Class 1 represents irrigable land with potentially high productive value; class 2 represents land of intermediate value, and class 3 includes land of the lowest value that may be suitable for irrigation. Table 1 lists the criteria used for each class.

The intensity of this land classification is a general reconnaissance survey. Any future project development should be based on a detailed study to pinpoint the exact location and limits of the land best suited for irrigation.

The accompanying maps show the location of irrigable land in the basin.

The irrigable lands within the Upper Yellowstone Basin are generally a medium to light textured soil with a high to moderate lime content in the lower C horizon depths of 18 to 60 inches. The soil is generally shallow to gravelly substratum, the depths being from 12 to 30 inches. There are shallower to gravel soils which are nonirrigable.

The irrigable land areas are generally on benchland terraces near the Yellowstone river. The bench lands are generally have gravel layers overlying the sandstone and shale parent material, the sandstone is the dominant substrata just below the gravel.

The drainability of the land is generally favorable for irrigation. The salinity of the soil is low and a salt problem in the return flow should be minimum.

The Middle Yellowstone irrigable land is generally on benchland terraces or alluvial-colluvial slopes along the Yellowstone River. The irrigable lands have soils which are typical of fans and terraces along the Yellowstone River. A typical soil is the Wanetta series described in the Yellowstone soil survey. The series consists of well-drained, nearly level to sloping, clay loam soils on terraces of large stream valleys. The soils are formed from alluvium and are 20-40 inches deep over sand and gravel. The native vegetation is grasses and sagebrush. Elevation ranges from 3,000 to 3,400 feet. The annual precipitation is 12 to 14 inches, the mean annual temperature is 45 to 47° F, and the frost-free season is about 128 days.

A typical soil profile, would be from cultivated land with a surface of grayish-brown clay loam 8 inches thick. The subsoil is brown clay loam about 9 inches thick. The substratum is light brownish-gray gravelly light clay loam that contains light-gray threads and mottles of lime. Depth to loose, very gravelly sand is 26 inches.

RECONNAISSANCE LAND CLASSIFICATION SPECIFICATIONS
MISSOURI BASIN REGION, MONTANA
STATE WATER PLAN
MONTANA WATER RESOURCES BOARD - LAND CLASSIFICATION SECTION

(1)

Soil or Land Characteristics	Class 1* Only Slight Limitations	Class 2* Moderate Limitations	Class 3 Severe Limitations
Dominant texture of Root Zone	Fine sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to cl (sands with suff: cient w.h.c. can be included.)
Depth to: Clean sand, gravel and cobble	40" minimum	20" minimum	10" minimun
(A) Hard rock, Sandstone or non-saline Shale	60" minimum	40" minimum	30" minimum
Textural Modifers			
(Vol.) of tillage layer: Gravel (<-3") Cobble (3-10")	No problem in tillage < 15%	Moderate problem in tillage .15 to 50% <-3" < 15% (3-10")	Severe problem in tillage >-50% <-3" 15 to 50% 3-10"
(B) Stoniness of surface and tillage layer, stones generally greater than 12" in diameter.	No problem in tillage	Cultivation not impractical. Stones >12" diameter; occupy 0.01 to 0.1% of the surface, and 0.15 to 1.5 cubic yards per acre foot.	Cultivation im- practical unless cleared. Stones >12" diameter; occupy 0.1 to 3% o the surface, and 1. to 50 cubic yards per acre foot.
(B) Rockiness (Small out- crops within Soil type)	No problem in tillage Less than 2% of bedrock exposed.	≈2% of surface may have bedrock exposed	2 to 10% surface may have bedrock exposed

In areas where use has demonstrated suitability, more severe modifiers can be rated irrigable for special uses not requiring tillage.

These soils are used for irrigated row crops, small grains and for range.

The soil drainage of the slopes and terraces is generally very good with very little salinity or alkalinity hazard.

The irrigable terrace and benchlands extend along the Yellowstone and Lower Bighorn rivers.

The Tongue River Valley irrigable lands are located on alluvial terraces and slopes near the river. The irrigable areas are intermixed within the existing irrigation and have variable soils which are loamy sand to clay textures. The drainage may be questionable in spots, however, in general the seepage is minimum, and any drainage problems are generally of a small area. Full utilization of the irrigation potential along the Tongue River is not fully developed. There are some problems of saline, alkali soils in spots, however, determining severity is difficult and will require a detailed study. The reconnaissance land classification has shown the drainage and salinity problems are not extensive.

The irrigable land of the Powder River Valley is the main area for irrigation reservations. The present land use is range, dryland hay and irrigated hayland. The irrigated lands receive one to two irrigations in early spring. The method of irrigation is pumps distributing large heads of water into dike systems. The limiting factor being the low water supply in July and August, plus a major problem of high silt loads in water during spring runoff and also late season.

The soils are variable alluvium on the floodplain areas. The surface textures are from a loam to clay texture, with the clay loams and silt loams being the dominant texture. The sub soil is generally from a medium to very light texture, depending upon the past alluvial action of the river. The old river loams are generally heavy textured to at least 60 to 100 inches. The majority of the area is a floodplain deposit which are of a very light substratium of sands and loamy sands, at depths from 12 inches and below. The sub-drainage in most cases will be very good.

The salinity of the soil is low to high amounts with the average being of medium salinity. Irrigation water will have to leach some salts from many areas, however, the presence of light to very light textured sandy sub stratium should allow good leaching of salts.

The heavy silt loads of the Powder River have been a detriment to irrigation and will be a very high cost problem in pumping. New pump designs such as the Crisifulli has allowed for pumping of silty water with a minimum of pump repair costs, this factor has increased irrigation within the last few years.

The Lower Yellowstone Valley is one of the most productive irrigated areas in Montana. The remaining irrigable land is generally above the present irrigation, also the soils are not generally of as high quality, however, there are large acreages which would be favorable for irrigation development.

The soils will vary from a clay to loam surface and subsoil. The majority of the irrigable lands are fans and terraces above the Yellowstone floodplain. The soils are generally deep, well-drained, nearly level to sloping. These soils are formed in old alluvium.

The permeability is moderate, and the available water capacity is high. The soils are used for crops and range. The presently irrigated lands are highly productive, and crops grown are barley, alfalfa, and sugar beets. The sugar beets are one of the high productive cash crops which add a very worthwhile economic industry to the lower Yellowstone area.

Soil or Land Characteristics	Class 1* Only Slight Limitations	Class 2* Moderate Limitations	Class 3 Severe Limitations
Available water-holding capacity (to a maximum depth of 4 feet)	> 6"	> 4"	> 2"
Permeability	Moderately slow - .20 inches per hour to moderate - 2.00 inches per hour, may exceed 2 inches per hour if sufficient water holding capacity is maintained - by field observation of soil texture, structure, etc.	Slow - .06 inches per hour to moderately rapid - 2.00 to 6.30 inches per hour - by field observation of soil texture, structure, etc.	Very slow - less than .06 inches per hour only in thin layers. To rapid - greater than 6.30 inches per hour if upper 4 Feet ~~lift~~ of soil has sufficient water holding capacity - by field observation of soil texture, structure, etc
Salinity and/or Alkalinity	Electrical conductivity not to exceed 4 millimhos/cm. may be higher under good leaching and drainage conditions. But not to exceed 8 millimhos/cm in top 4 ft.	Electrical conductivity not to exceed 8 millimhos/cm; except under good leaching and drainage conditions. Most horizons will have less than 8 millimhos/cm.	Electrical conductivity not to exceed 8 millimhos/cm in top 2 feet. Lower horizons may be higher under good leaching and drainage conditions, but not to exceed 15 millimhos/cm.

Slight or moderate salinity or alkalinity may exclude soils from Classes 1 thru 3 if associated with either or both a slow permeable substrata, or saline shale. Exchangeable sodium greater than 3.0 millequivalents per 100 grams and/or sodium adsorption ratio greater than 12 of soil for cation exchange capacities less than 25 millequivalents per 100 grams - may exclude a soil from irrigable class if leaching is not practical.

(3)

Soil or Land Characteristics	Class 1* Only Slight Limitations	Class 2* Moderate Limitations	Class 3 Severe Limitations
Topography			
Slope	0-4%	< 8%	15% (Sprinkler irrigation on slopes > 8%)
Drainage			
(C) Water Table	Easily maintained below 5' depth during growing season.	Practical to maintain below 40" depth most of the time in growing season (requires drainage)	Can maintain below 20" most of the growing season.
Overflow	No over flow	Free of overflow in growing season	Overflow may be hazard to crops in some years (2 or 3 in 10)
Climate			
	Growing season greater than 90 days.	Growing season greater than 90 days.	Growing season may be less than 90 days.

Footnotes:

*Any one deficiency below the limits of a class is cause for downgrading to next lower class. Two or more ~~such~~ such deficiencies may cause downgrading two classes if judgement indicates they are additive in effect. Combinations of less severe deficiencies will be evaluated on a judgement basis.

(A) Soils known to be underlain by saline shale at depths as shallow as 60 inches are excluded from Class 1 through 3.

(B) For detailed description see Soil Survey Manual U.S.D.A. pp 217 & 220.

Class 1 through 3 are permeable enough to permit leaching of salts when drainage

Surface Water Resources

The Yellowstone River has a drainage area of 70,115 square miles which is divided nearly equally between the states of Montana and Wyoming. The river rises in northwestern Wyoming, runs into Yellowstone Lake and then flows in a northerly direction to Livingston, where it turns eastward to Laurel, the northeastward to Sidney joining the Missouri River a few miles east of the Montana-North Dakota stateline. A map of Montana's portion of the basin, with 1970 level of development flows illustrated is shown on map ____. These flows are averages calculated from historical records (that have been) modified to show the effects of 1970 level depletions in each year of history. For the Yellowstone mainstem at Sidney this flow is 8.8 million acre-feet per year, while the unmodified historical flow is about 9.5 million acre-feet per year. At their point of confluence the Yellowstone yields 22 percent more annual flow than the Missouri though it drains 14 percent less area. The basis for these flow figures and other hydrologic information presented in this report are records gathered at some of the U.S. Geological Survey gaging stations located throughout the basin as shown on map ____.

The Yellowstone River receives more than one-half of its total flow from the mainstem and tributaries rising in mountain ranges above Billings. The majority of flow entering the mainstem below Billings comes from the Bighorn, Tongue, and Powder Rivers. Water resources available for use in the basin depend largely on melting snows in the high country of Montana and from water passing the state line from Wyoming. Snowmelt is augmented to a lesser degree by summer rainstorms. Hydrologic characteristics vary within the basin, primarily between the mountain and plains region. As shown on map ____ water yield from the high mountain region ranges up to 40 inches while there is almost no run-off from the semiarid plains regions. Many perennial streams are seen in the

mountainous areas while in the simiarid regions the only streams that normally flow year round are the large interstate tributaries. Seasonal distribution of runoff also varies from west to east in the basin. Figure _____ shows the hydrograph of the Yellowstone River at Livingston and is typical of western mountainous snowpack drainages. Most of the annual runoff ~~come out~~ occurs in spring and early summer and then the flow drops sharply as the snowpack is depleted, with the flow then modified by irrigation diversions and rains. The annual low flow generally occurs in winter months. Figure _____ shows the hydrograph of the Powder River at Locate which is typical of a plains region stream. Much of the runoff can be derived from chinook winds melting low elevation snowpack in winter months while a second period of high flow in early summer is due to higher elevation snowpack and possible summer rains. The ~~years~~ lowest flows usually occur in early winter. Tremendous variation in flow is shown by plains streams with high flows of short duration contrasted by flows approaching and reaching zero at other times of the year.

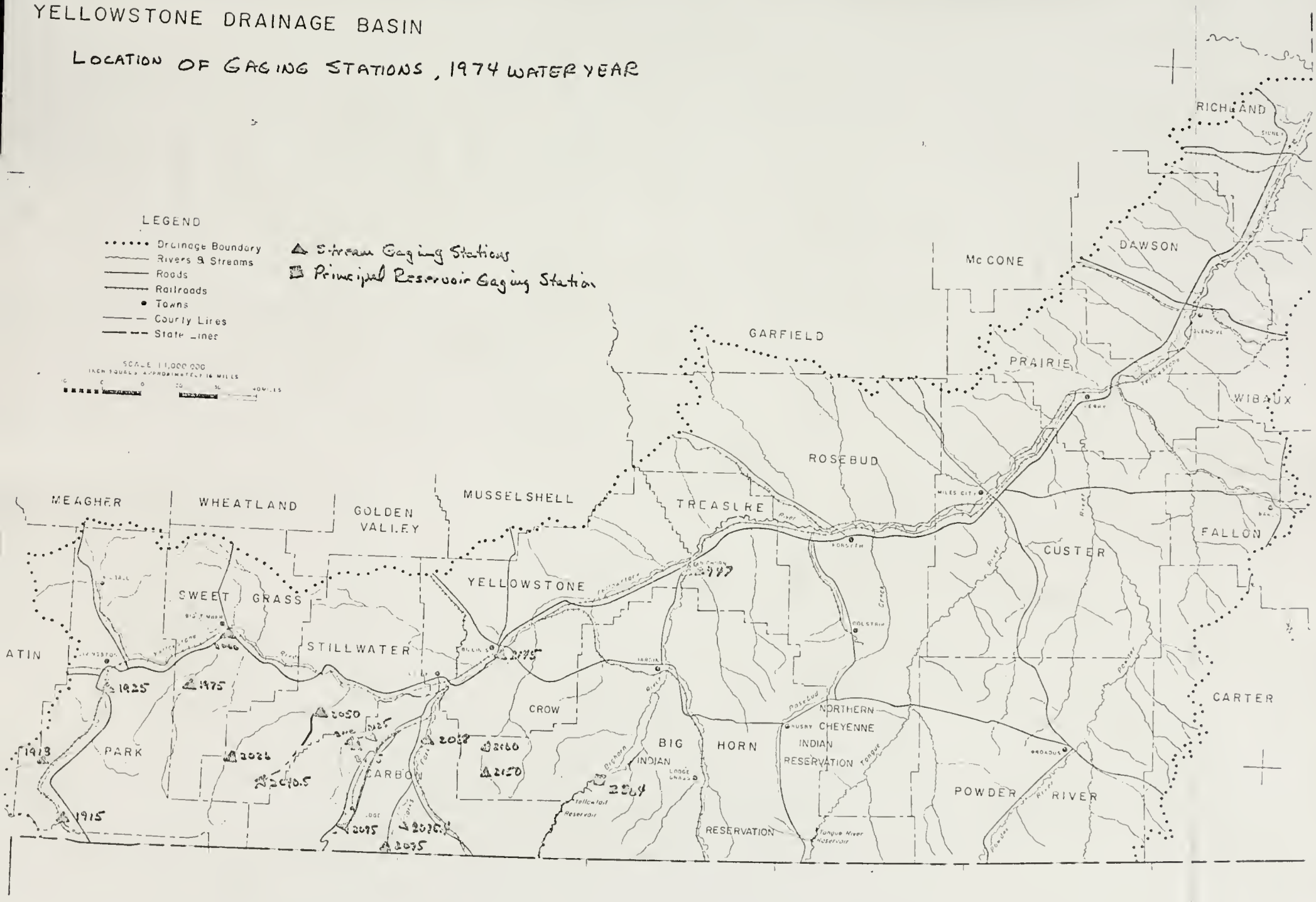
For more detailed description of the basin's water resources, the basin has been divided into the Upper, Middle, and Lower subbasins as shown on map _____.

GEOMORPHOLOGY

Roy Koch's description of the channel process that have formed the Yellowstone as we know it today. Available sometime in August.

YELLOWSTONE DRAINAGE BASIN

LOCATION OF GAGING STATIONS, 1974 WATER YEAR



Map 2

YELLOWSTONE DRAINAGE BASIN
MONTANA

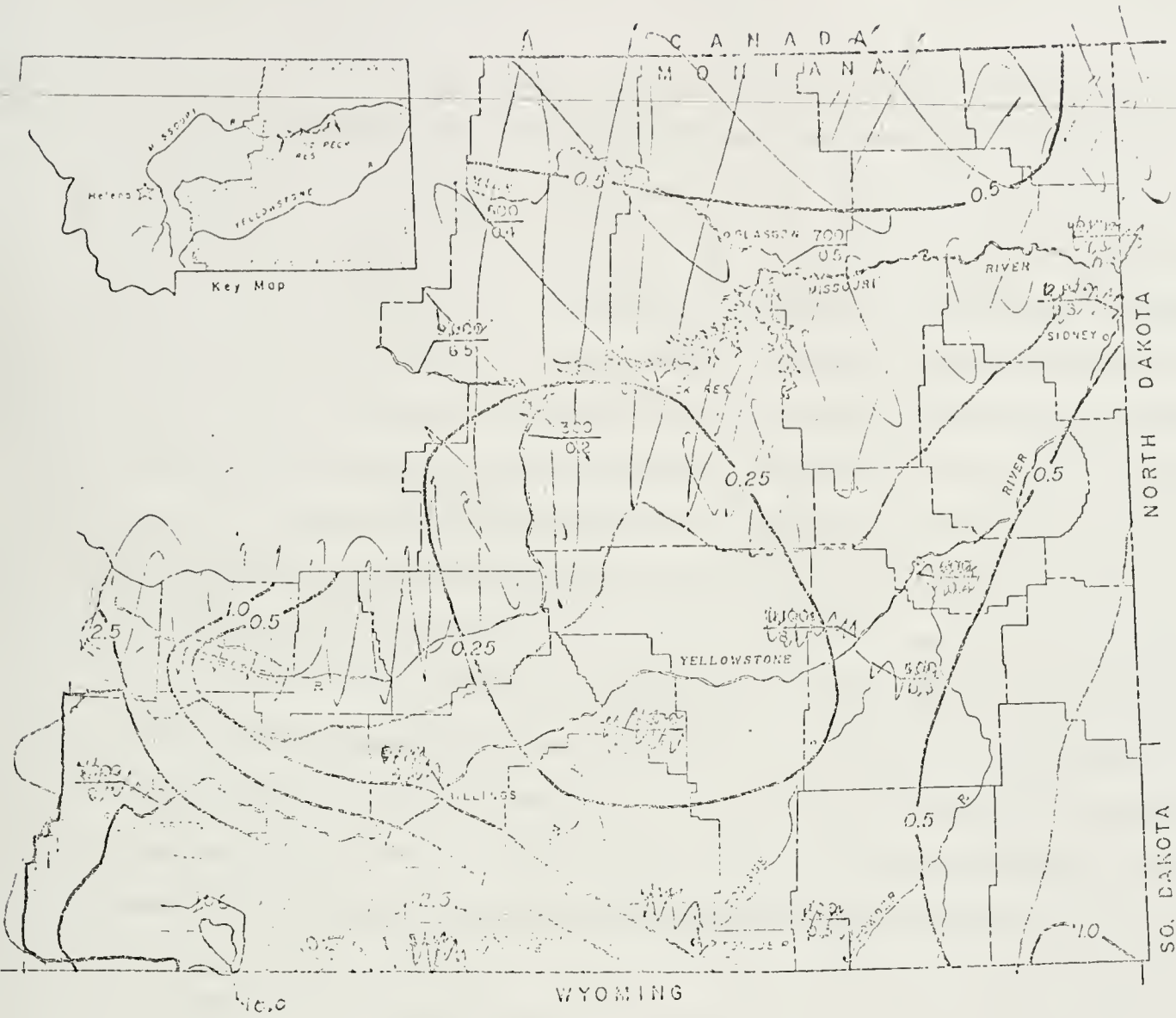
MEAN ANNUAL RUNOFF

Figures given in block are in millions of acre feet per year.

Width of stream line corresponds to top width of channel. Mean annual discharge, in thousands of cubic feet per second, is represented by channel cross section in blue.

- Drainage Boundary
- Rivers & Streams
- Roads
- Railroads
- Towns
- County Lines
- State Lines

SOURCE:
EARTH SCIENCE DEPT. M.S.U. BOZEMAN,
WORK GROUP-NORTHERN GREAT PLAINS RESOURCES PROGRAM.



EXPLANATION

0.5 — AVERAGE ANNUAL RUNOFF IN INCHES PER UNIT AREA

3,900 / 2.7 — AVERAGE ANNUAL STREAMFLOW IN CUBIC FEET PER SECOND OVER VOLUME OF STREAMFLOW IN MILLION ACRE FEET PER YEAR.

EASTERN MONTANA BASINS

AVERAGE ANNUAL RUNOFF AND STREAMFLOW

INFORMATION SOURCE: 82

SCALE OF MILES

1237-604-43

1. Upper Yellowstone River Basin

The Upper Yellowstone River Basin includes the Yellowstone River mainstem from the Yellowstone National Park Boundary to the confluence of the Clarks Fork Yellowstone River and the following major tributaries, Clarks Fork Yellowstone River, Shields River, Boulder River, Sweetgrass River, Stillwater River.

Streamflow records indicate that peak flows in the Upper Yellowstone River Basin generally occur from mid-June to mid-July and are caused by snowmelt from mountain snow pack. These mountain snowpacks are the major contributing factor to the stable and usually plentiful runoff experienced in most years. In the lower plains region of this basin peak runoff can occur in mid-winter as a result of chinook winds. Natural regulation of the mainstem Yellowstone is provided by Yellowstone Lake in Yellowstone National Park.

Figures _____ through _____ summarize stream flow information for the Yellowstone and Clarks Fork Yellowstone Rivers. Figures _____ and _____ are general representations of low flow duration curves for 1, 30, and 90 consecutive day low flows. For example, on the Yellowstone River near Livingston, a one-day low flow of 750 cubic feet per second (cfs) is equalled or exceeded 80 per cent of the time, in other words, ~~that~~ a lower flow can be expected to occur in only 2 of 10 years.

The maximum flow recorded for the mainsteam near Livingston was 36,300 cfs on June 17, 1974, while the lowest was 590 cfs on January 22, 1940, similar flows for the Clarks Fork Yellowstone are 10,900 cfs on June 7, 1936 and 36 cfs on April 22, 1961.

The following reservoirs are located in the Upper Yellowstone River Basin.

TABLE ____

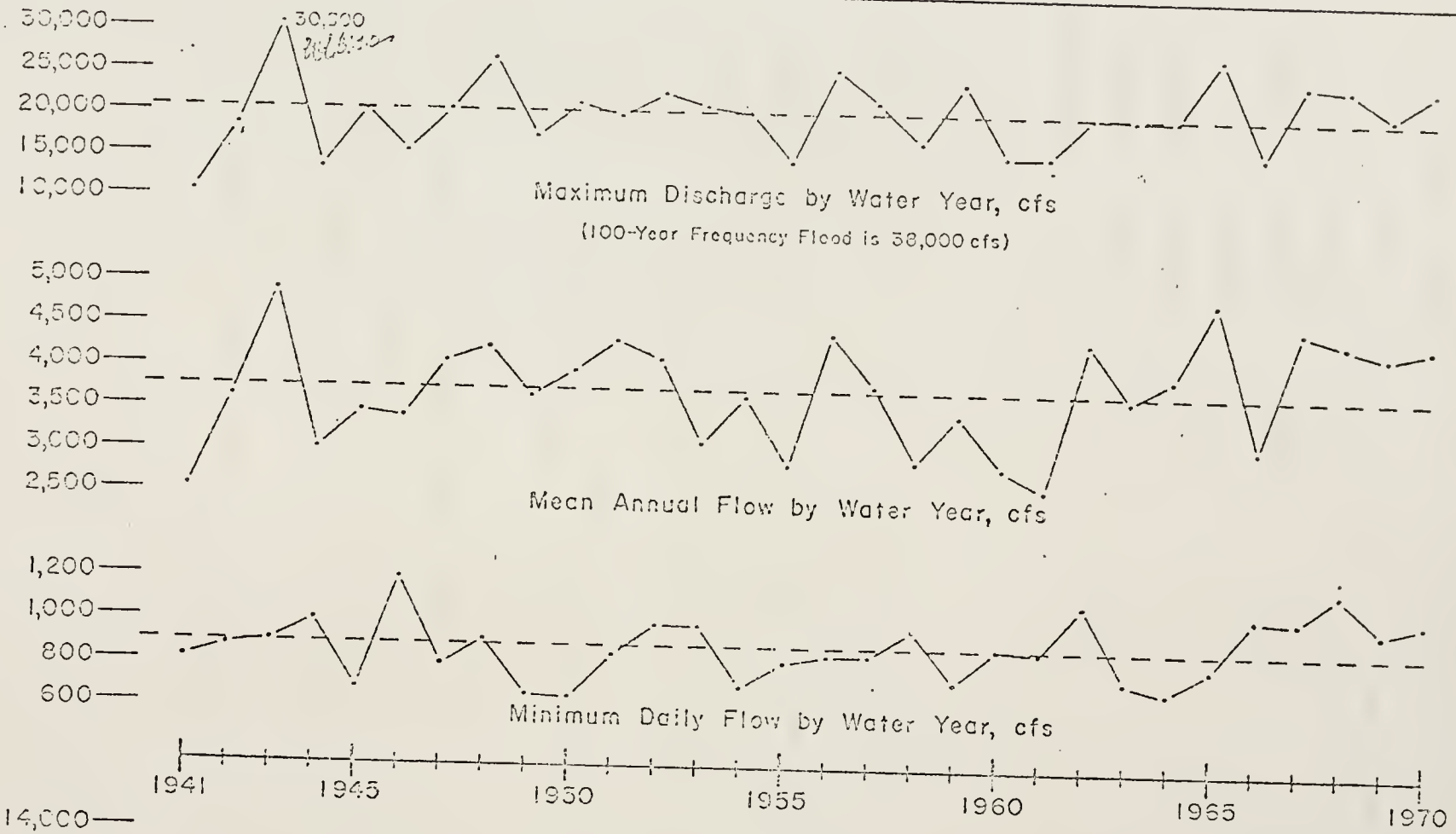
Reservoirs With Total Capacity of 5,000 Acre-Feet or More 1/

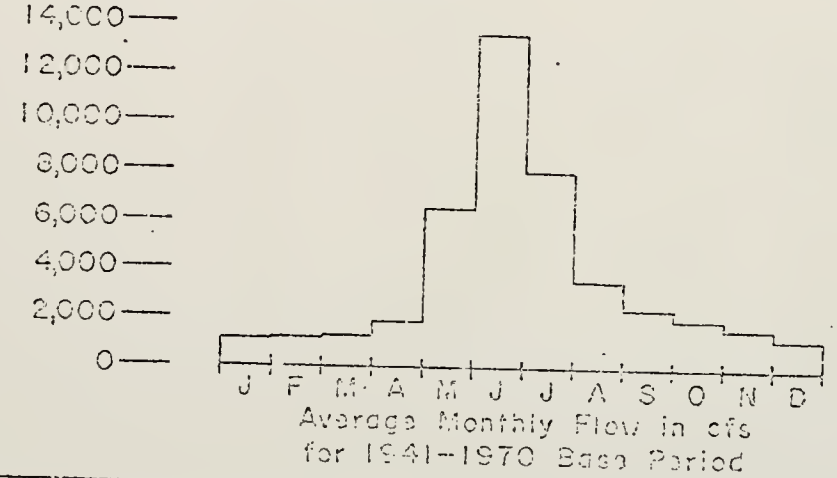
Upper Yellowstone River Basin

NAME	STREAM	TOTAL STORAGE	ACTIVE STORAGE	SURFACE AREA	PURPOSE
Cooney	Red Lodge Creek	24,190 AF	24,190 AF	790 Acres	Irrigation
Lake Adam	Sweet Grass Creek	11,000 AF	11,000 AF	585 Acres	Irrigation
Lake Wolvoord	Sweet Grass Creek	14,000 AF	14,000 AF	768 Acres	Irrigation
Mystic Lake	West Rosebud Creek	20,800 AF	20,800 AF	400 Acres	Hydropower

1/ Framework Report, Volume 1, Department of Natural Resources and Conservation, July 1976.

These reservoirs coupled with stockponds can influence the hydrology of small streams by reducing peak flow and increasing low flows in effect stabilizing the stream. This effect also normally changes island and bar formation, bank vegetation and river meander. It is doubtful however that the reservoirs in the upper basin influence, except to a very minor degree, the mainstem.

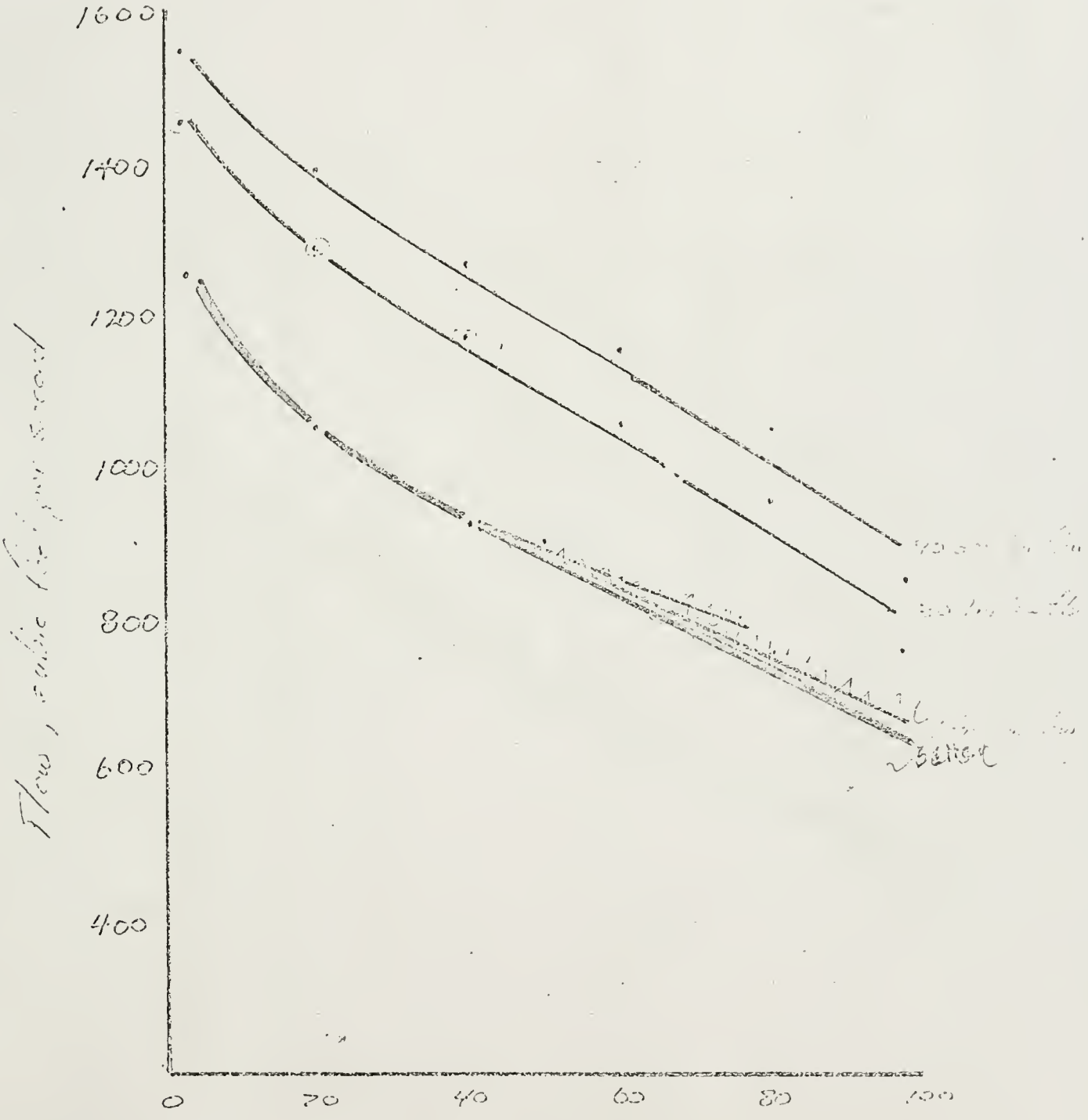


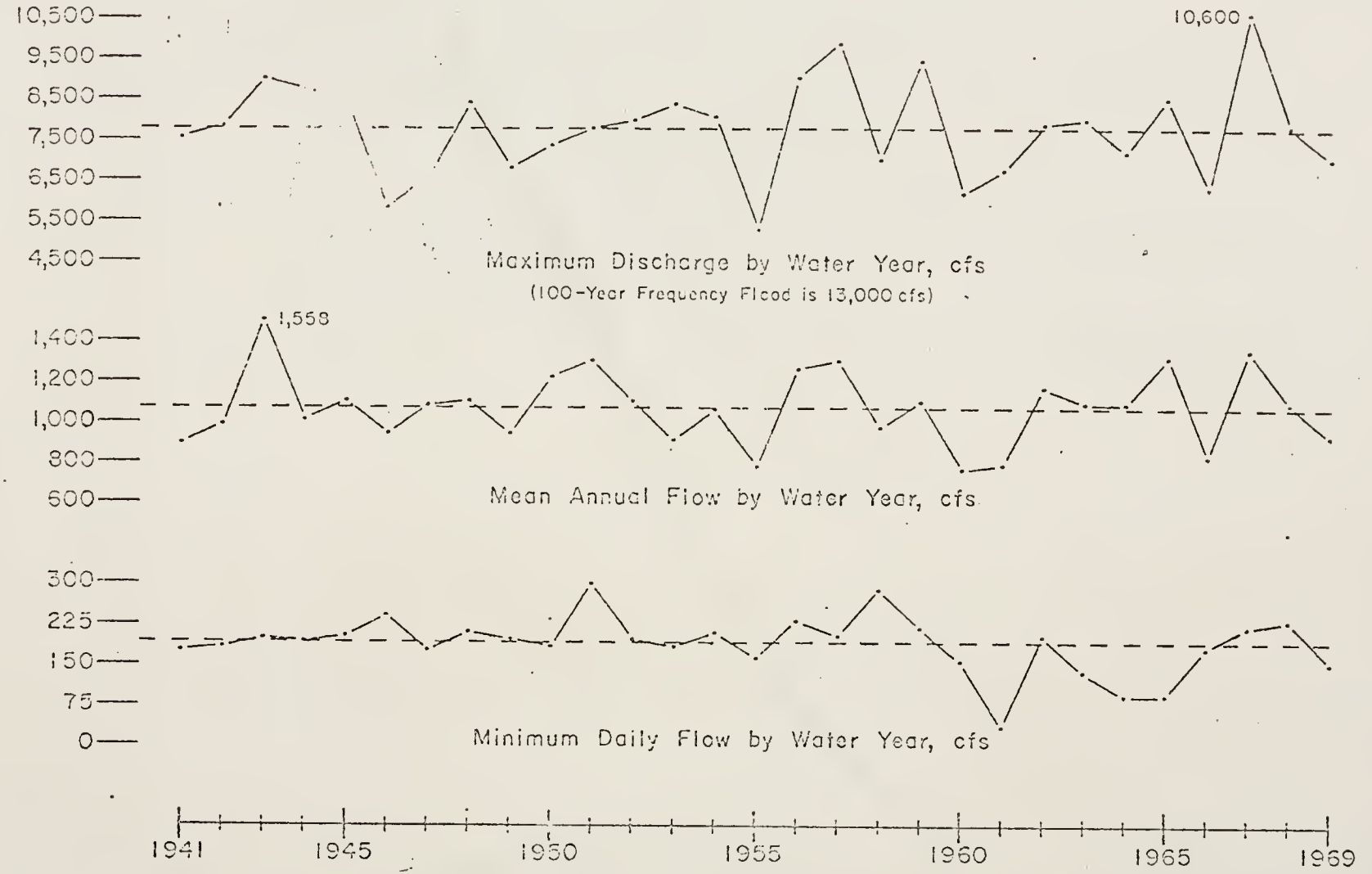


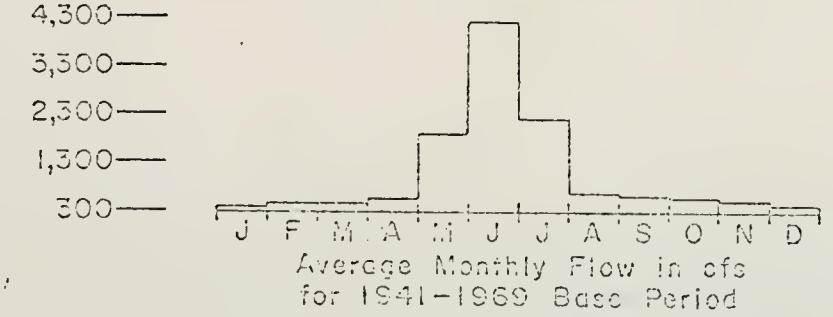
YELLOWSTONE RIVER NEAR LIVINGSTON
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06192500
Drainage Area 3551 sq. mi.
Period of Record 1897-1905; 1928-1932
1937-Present

YELLOWSTONE RIVER NEAR LIVINGSTON

Low Flow Duration Curves







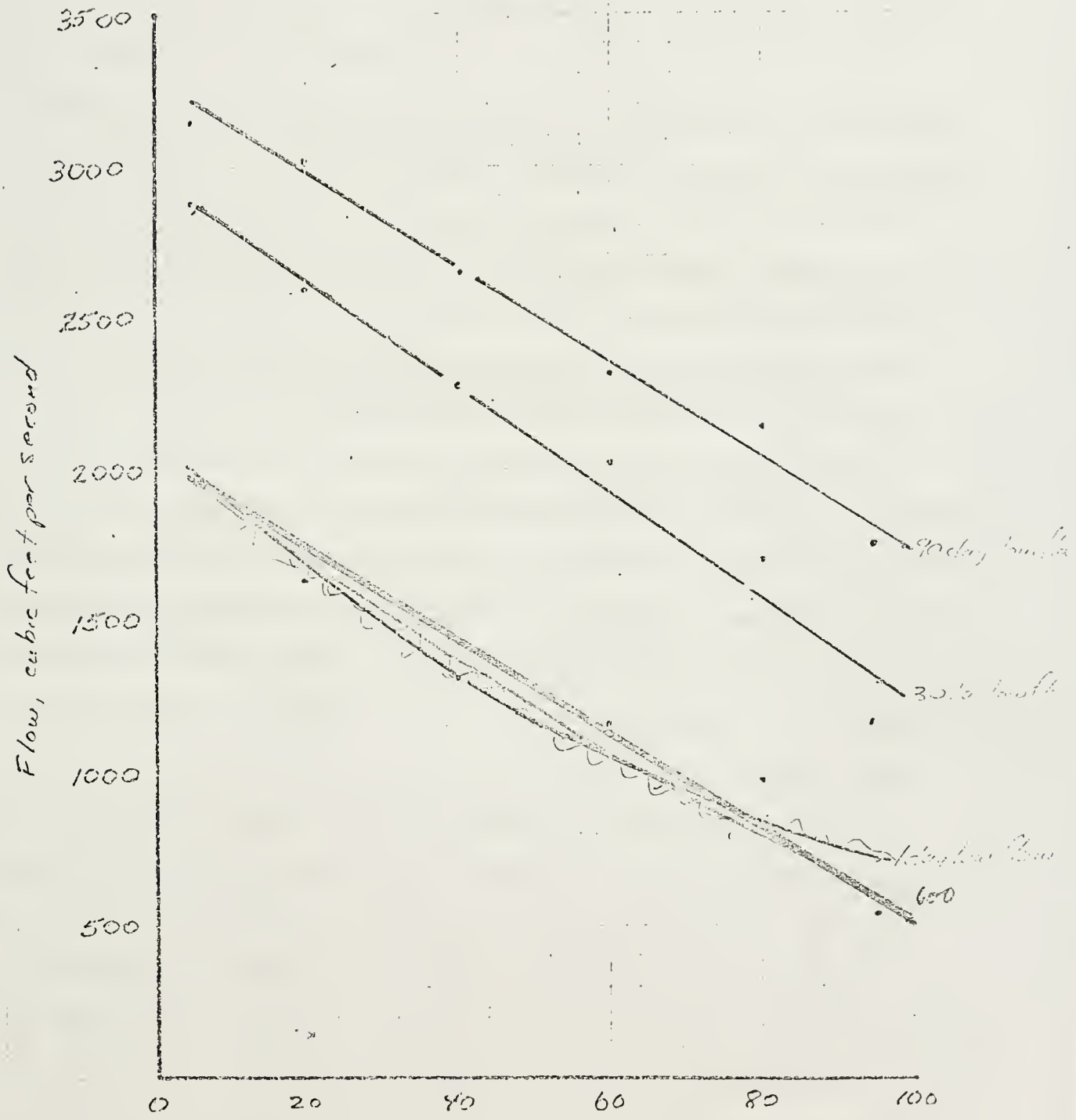
CLARKS FORK YELLOWSTONE AT EDGAR

YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06208500
Drainage Area 2032 sq. mi.
Period of Record 1921-1969

Yellowstone River at Billings

Low Flow Duration Curves

Period of Record 1930-1973



2. The Middle Yellowstone River Basin

The Middle Yellowstone River Basin includes the Yellowstone River Mainstem from the confluence of the Clarks Fork Yellowstone to the confluence of the Tongue River and the following major tributaries, Pryor Creek, Bighorn River, Rosebud Creek and the Tongue River.

As in the Upper Yellowstone River Basin the streams of the Middle Yellowstone River Basin display different hydrologic characteristics depending on whether their source is in the mountains or plains region. There are drastic variations in daily, monthly and, annual flow for streams orginating in the prairie region. The spring runoff for these streams generally occur between March and May and can cause a minor peak in the flow of the Yellowstone River. However, the major peak flow period for the Yellowstone mainstem and tributaries originating in mountanious areas is usually between mid-June to mid-July, since the runoff is from mountain snowpack in the rivers upper drainage. The semi-arid portions of this basin give rise to streams whose variations are extremely variable and peak flows that can occur in mid-winter due to chinook winds. Normally, however, these high flows will generally come sometime between late winter and early spring. Little vegetation and soils of low infiltration capacities are characteristics of these basins and favor rapid runoff and changes in flow.

Figures _____ through _____ show hydrologic characteristics of the Yellowstone River at Billings, the Bighorn River at Bighorn and the Tongue River at Miles City. The maximum discharge recorded for the Yellowstone River at Billings was 69,500 cubic feet per second on June 19, 1974, while the minimum was 430 cubic feet per second on December 12, 1932. The Tongue River has been regulated by Tongue River Reservoir since 1939 and the maximum flow recorded was 13,500 cubic feet per second on June 15, 1962 while the minimum was zero on July 9-19,

August 13,14 and September 28, 1940. The Bighorn River has been regulated by Yellowtail Reservoir since November 3, 1965 and the maximum flow recorded was 26,200 cubic feet per second on June 24, 1942, while the minimum was 275 cubic feet per second on November 15, 1959. Figure _____ is a general representation of the low flow duration curves for 1, 30, and 90 consecutive day low flows.

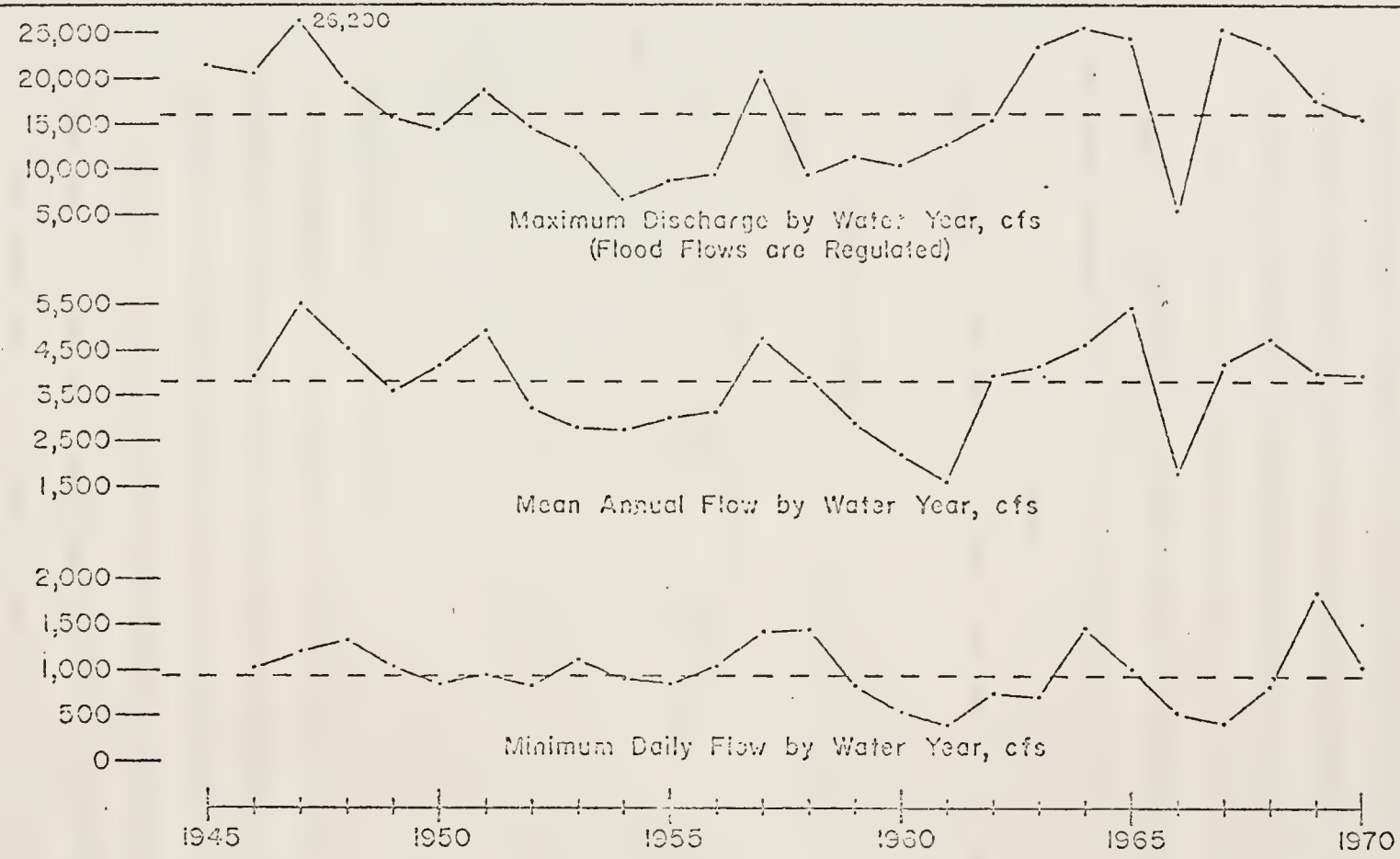
For example, on the Tongue River at Miles City, a 30 consecutive day average low of about 8 cfs is equalled or exceeded 80 percent of the time, in other words, a lower flow can be expected in only 2 of 10 years.

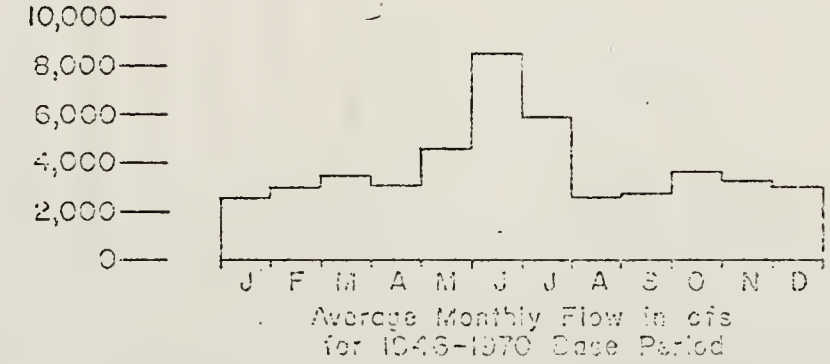
Reservoirs in the Middle Yellowstone River Basin are shown in Table _____.

TABLE _____
RESERVOIRS WITH TOTAL CAPACITY OF 5000 ACRE-FEET OR MORE 1/
MIDDLE YELLOWSTONE RIVER BASIN

Name	Stream	Total Storage	Active Storage	Surface Area	Purposes
Tongue River	Tongue River	69,439	68,040	3,497 Acres	Irrigation
Willow Creek	Lodge Grass Cr.	23,000	23,000	750 Acres	Irrigation
Yellowtail	Bighorn River	1,375,000	1,356,000	17,300 Acres	Irrigation Flood Control Hydropower Fish & Wildlif

While the Tongue River dam substantially modified the natural hydrologic characteristics of the Tongue River, these effects are little noticed on the relatively larger Yellowstone mainstem. However, the same is not true of Yellowtail Reservoir, because of the large amount of storage and yield of the Bighorn River, that system to some extent does influence the Yellowstone mainstem. The extreme low flows recorded in the mainstem downstream from the mouth of the Bighorn River would not have been as low if Yellowtail Reservoir had existed at that time. Both reservoirs have had some effect on island and bar formation, bank vegetation and other channel processes.





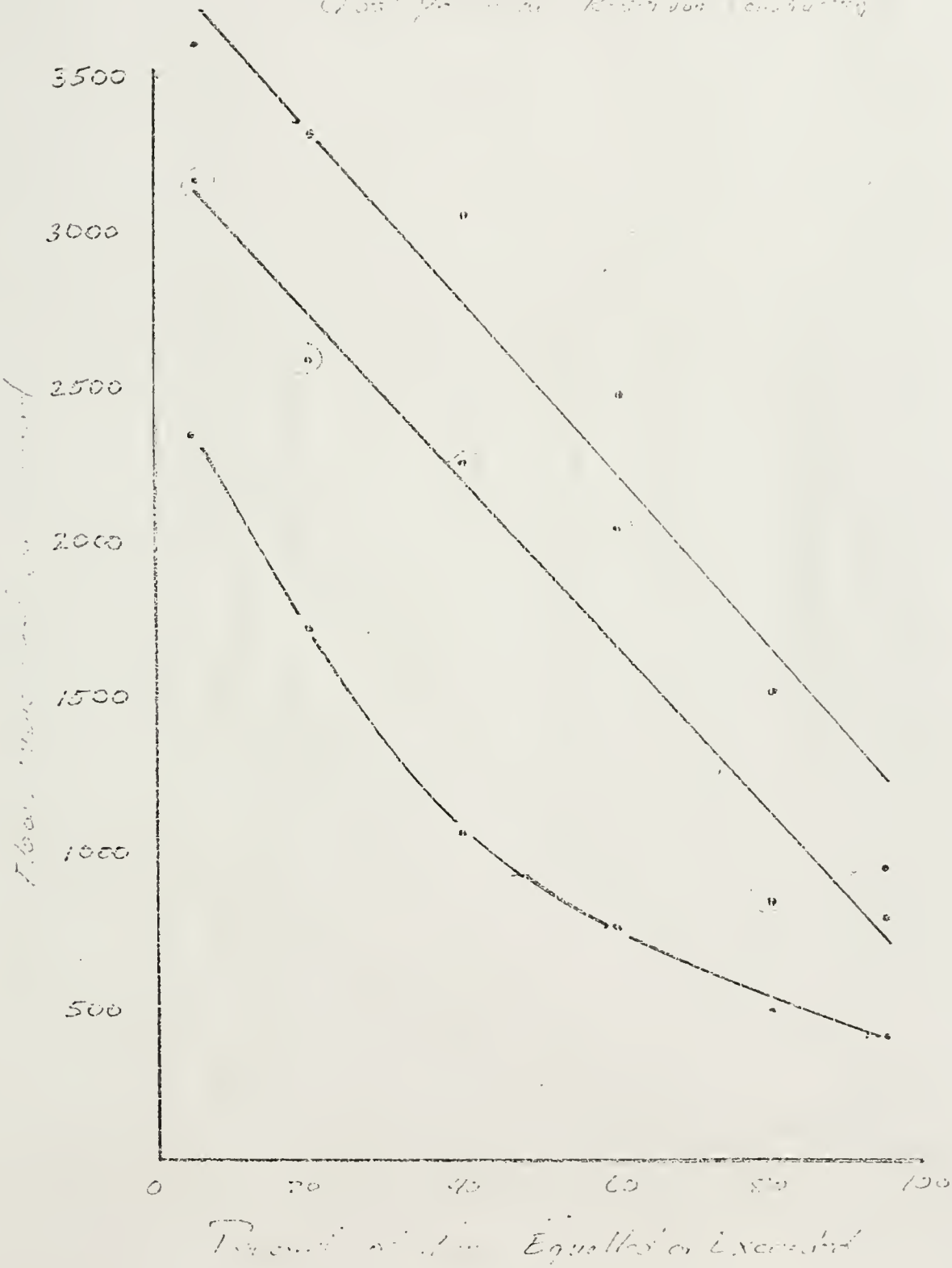
BIG HORN RIVER AT BIG HORN

YELLOWSTONE RIVER BASIN
U. S. G. S. Station No. 06294700
Drainage Area 22885 sq. mi.
Period of Record 1945-Present

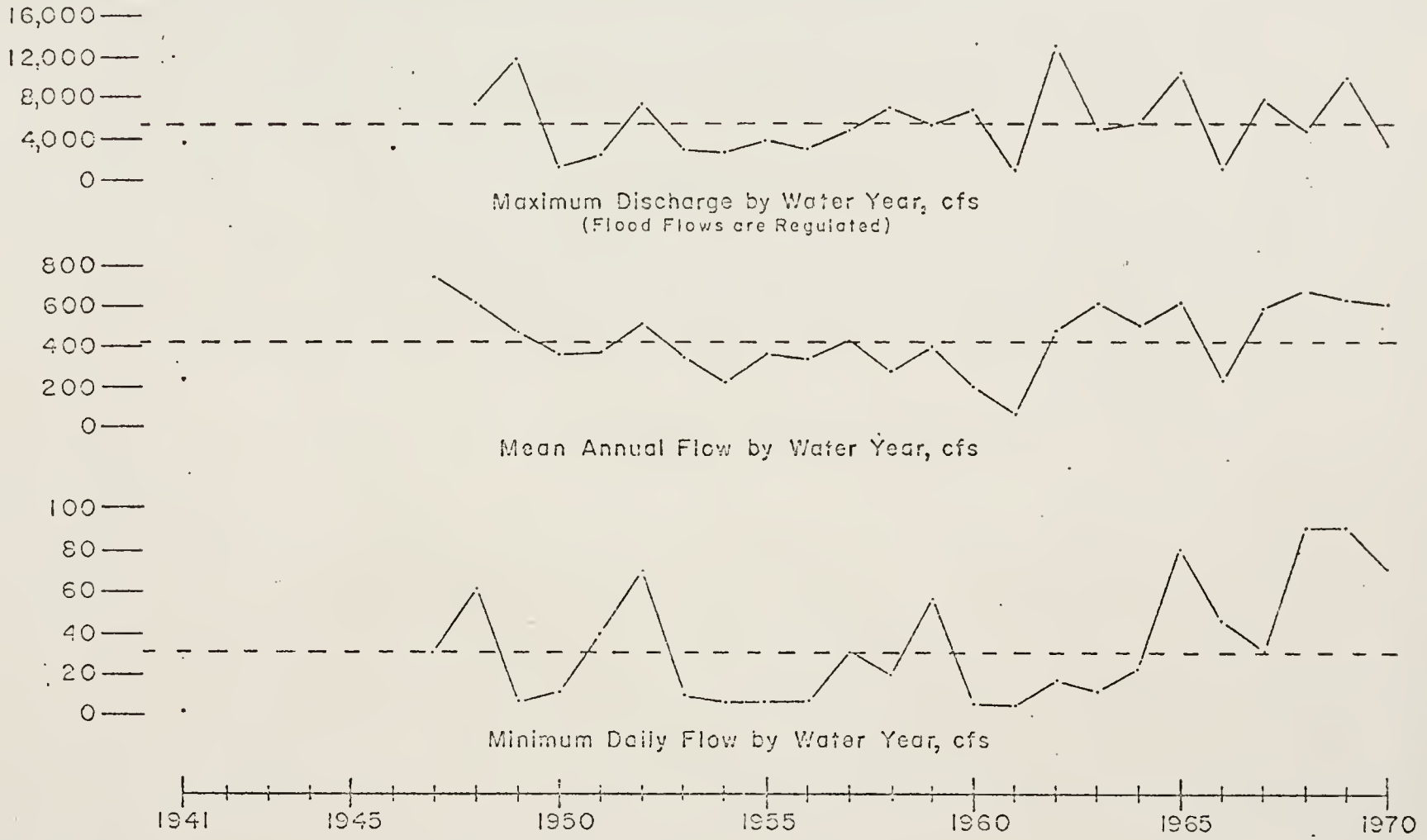
BIGHORN RIVER AT BIGHORN

Duration Curves

Period of Record 1962-1973



Percent of Time Equalled or Exceeded



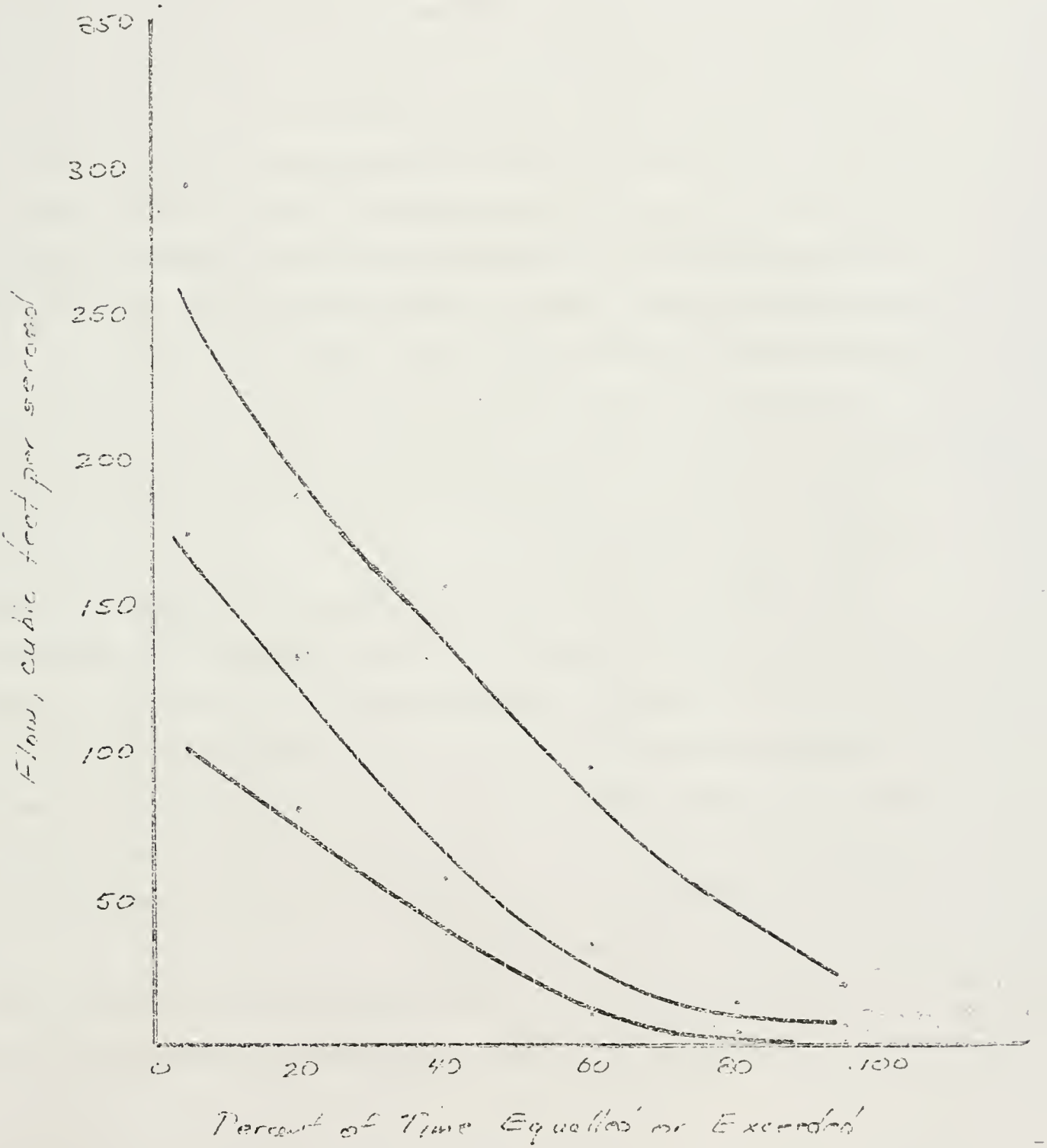
TONGUE RIVER AT MILES CITY

YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06308500
Drainage Area 5,379 sq.mi
Period of Record 1938-1942
1946-Present

Tongue River at Miles City

Low Flow Duration Curves

Period of Record 1939-1973



3. Lower Yellowstone River Basin

The Lower Yellowstone River Basin includes the Yellowstone River mainstem from the mouth of the Tongue River to the Montana-North Dakota State Line, and includes the following major tributaries of the Powder River and O'Fallon Creek.

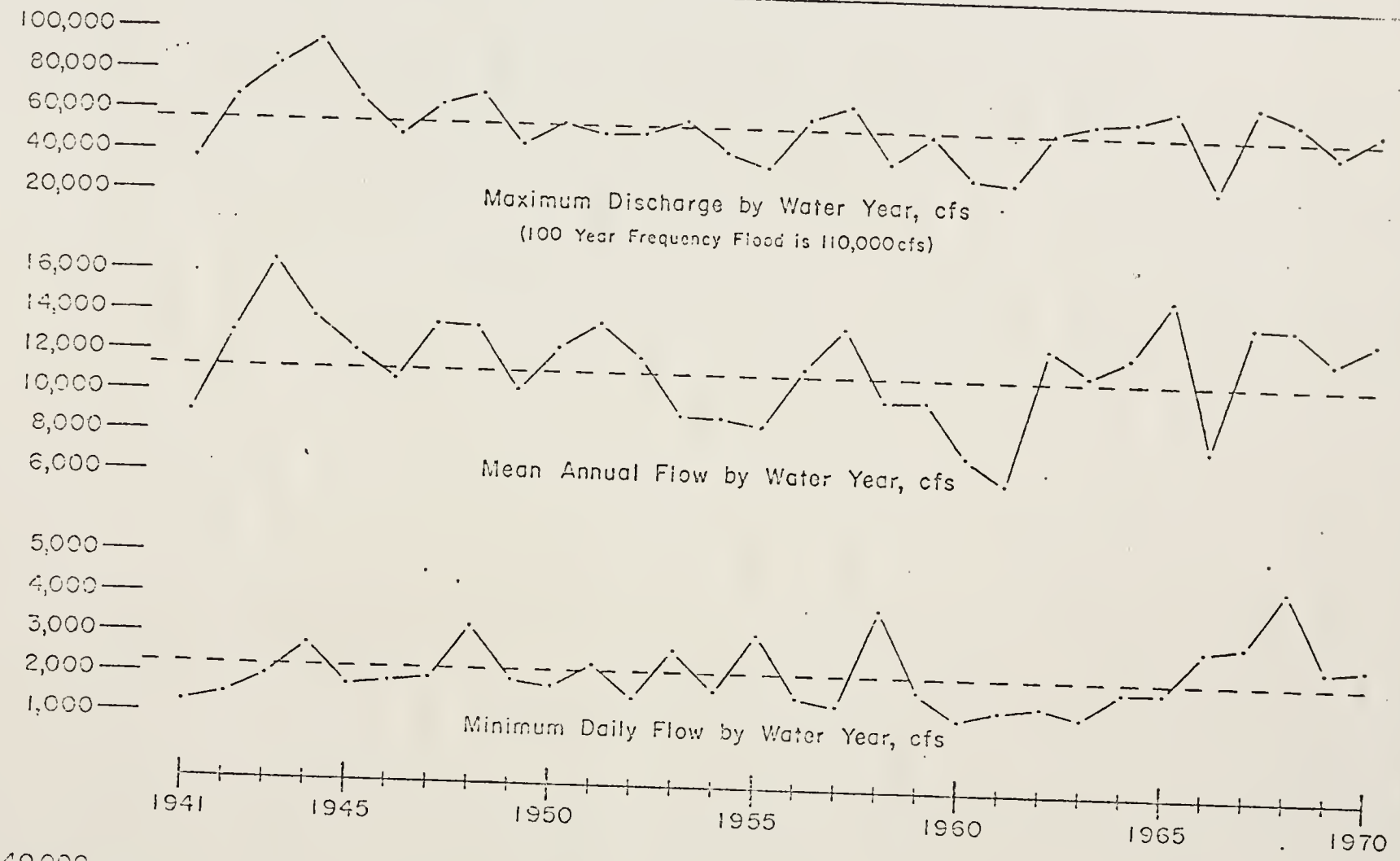
Streamflow records indicate that for many small tributaries in this basin the major portion of the annual flow comes during March and then is reduced to zero by summer. High flows also occur in the Powder River in March although as shown in Figure _____ the peak flows generally occur in June. The peak flows for the Yellowstone generally occur from mid-June to mid-July because of snowmelt from the basin's mountainous regions. Winter months of December and January generally bring the lowest flow of the year for major streams in this basin.

The Powder River is partially regulated by three reservoirs in Wyoming, while the Yellowstone mainstem is regulated to some extent by Yellowtail Reservoir on the Big-horn River. Irrigation can significantly affect flow in both the Yellowstone and Powder Rivers.

The maximum flow recorded for the Yellowstone River at Sidney was 159,000 cubic feet per second on June 2, 1921 while the minimum was 470 cubic feet per second on May 17, 1961. It is doubtful however that this minimum will again be approached because of the stabilizing effect releases from Yellowtail Reservoir have on the lower Yellowstone mainstem. The extremes for the Powder River near Locate is 31,000 cubic feet per second on February 19, 1943, and zero flow from January 16 to February 12, February 22-24, 1950, July 27, September 21-27, October 1, 1960, and September 4-8, 1961.

Figures _____ through _____ illustrate hydrologic characteristics of the basins. Figures _____, _____ and _____ are general representations of low flow

duration curves for three stations in the basin. For example, in the Yellowstone River near Sidney, a one day low flow of about 3200 cfs will be equalled or exceeded 20% of the time. In other words a lower one day flow can be expected, on the average, about 8 years of 10.



Average Monthly Flow in cfs
for 1941–1970 Base Period

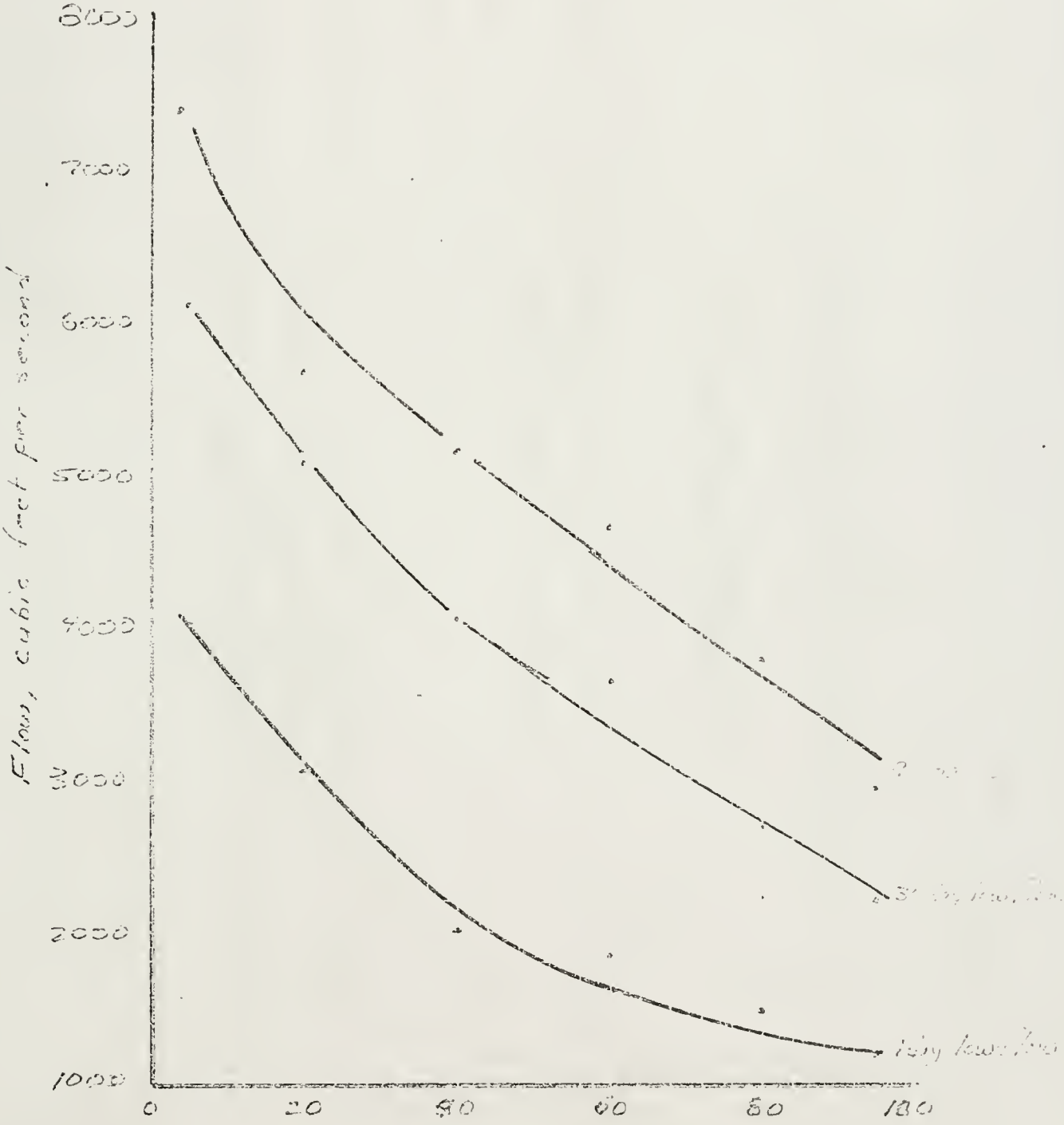
YELLOWSTONE RIVER AT MILES CITY

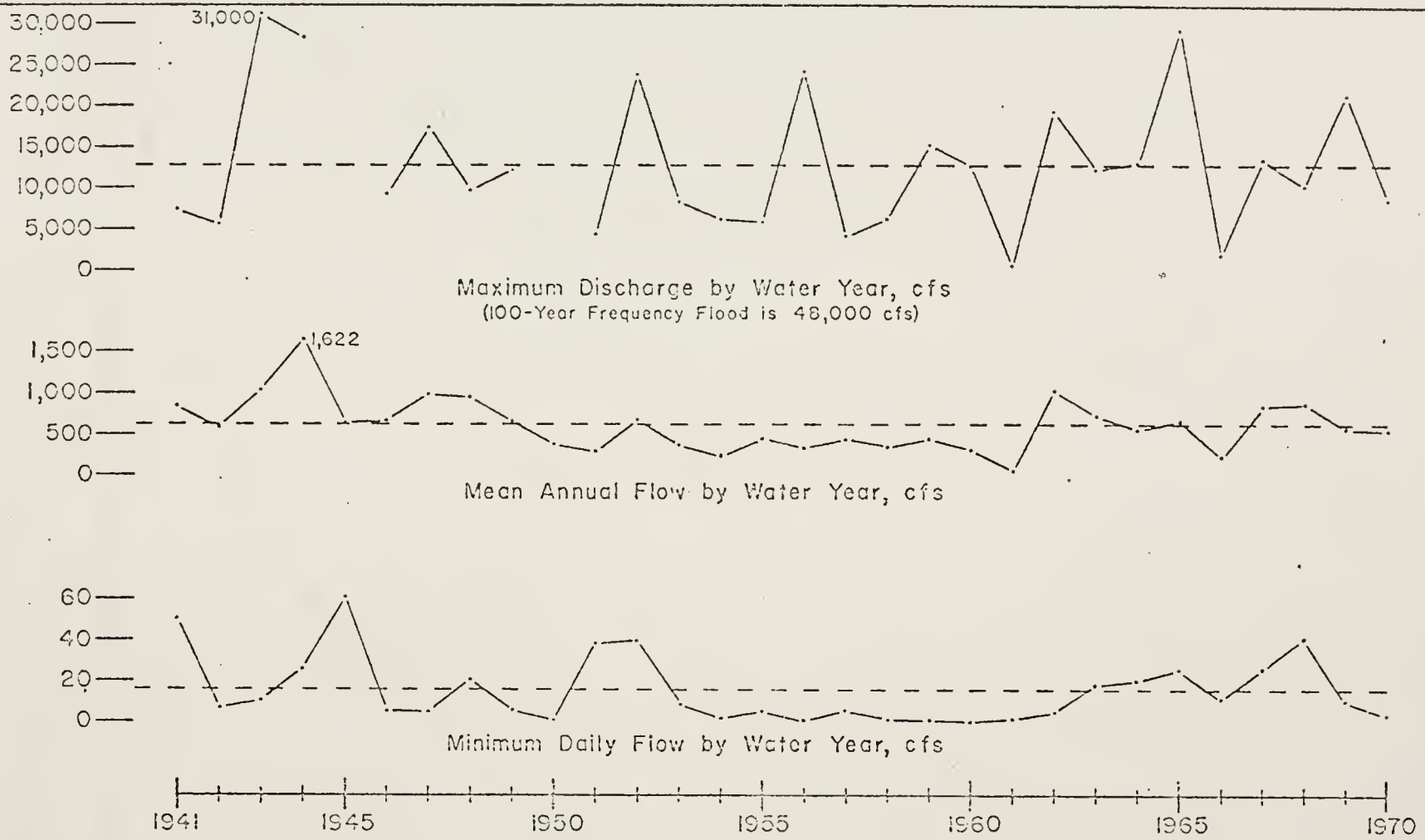
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06309000
Drainage Area 48253 sq. mi.
Period of Record 1922–1923
1928–Present

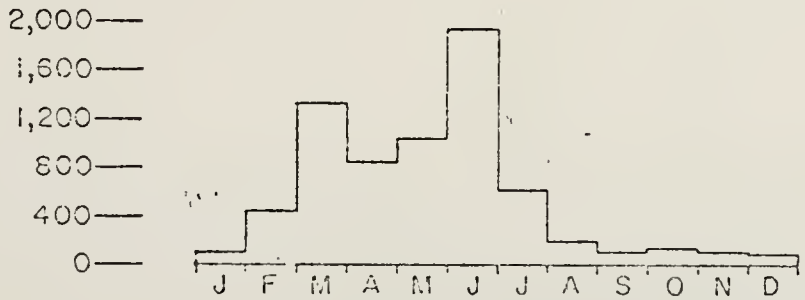
YELLOWSTONE RIVER AT MILES CITY

LOW FLOW DURATION CURVES

Period of Record 1931-1975







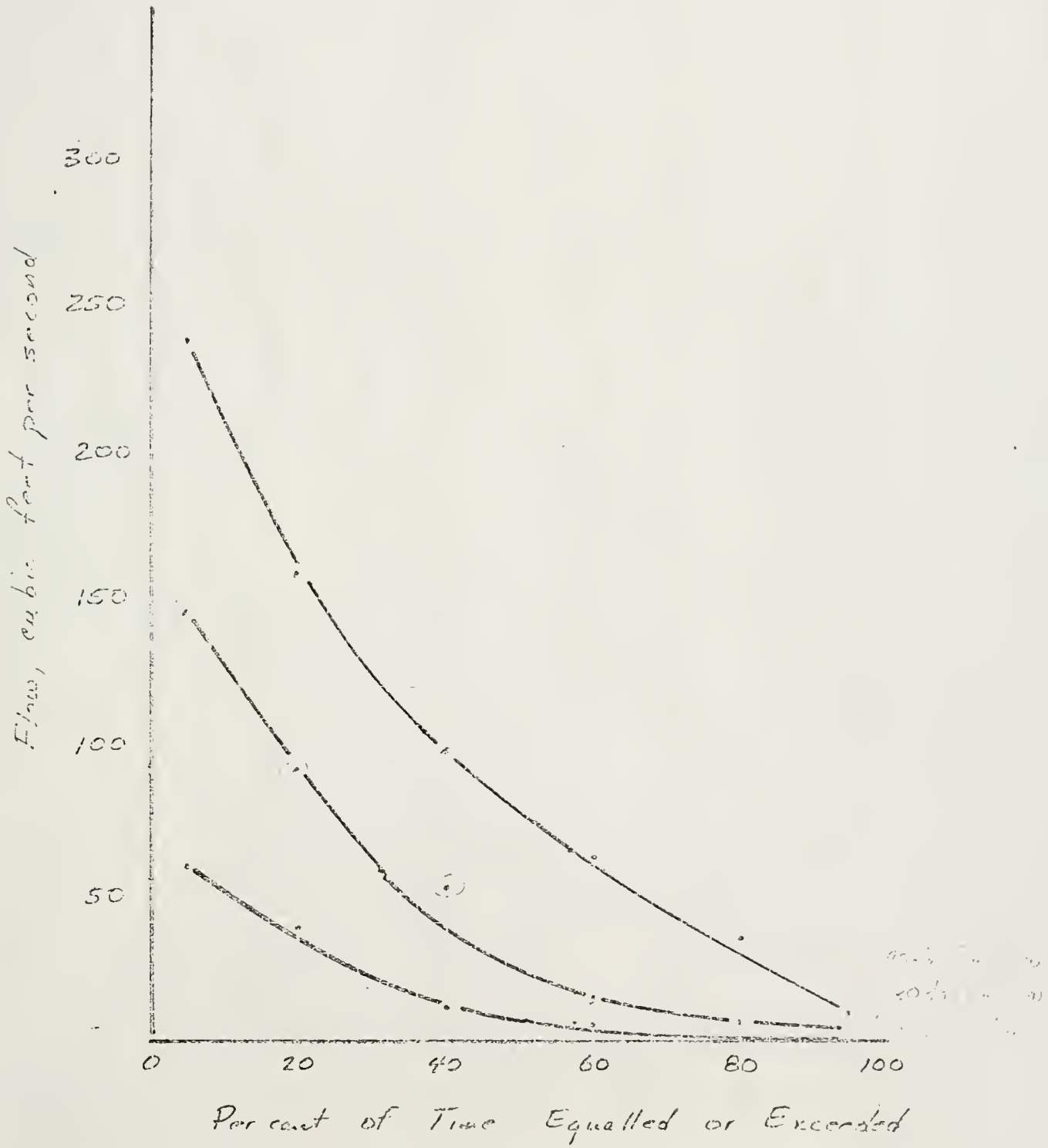
POWDER RIVER NEAR LOCATE

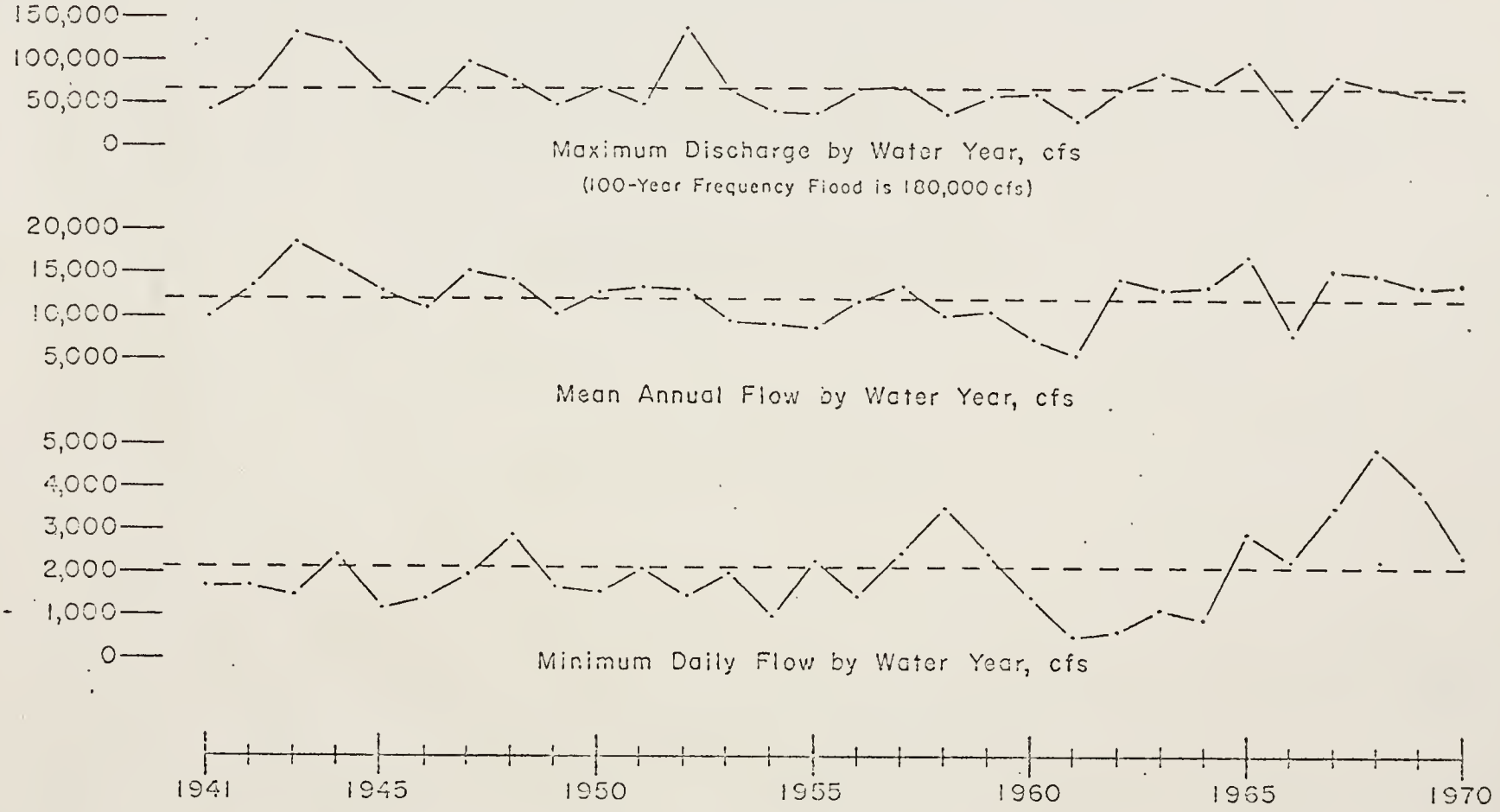
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06326500
Drainage Area 13139 sq. mi.
Period of Record 1938-Present

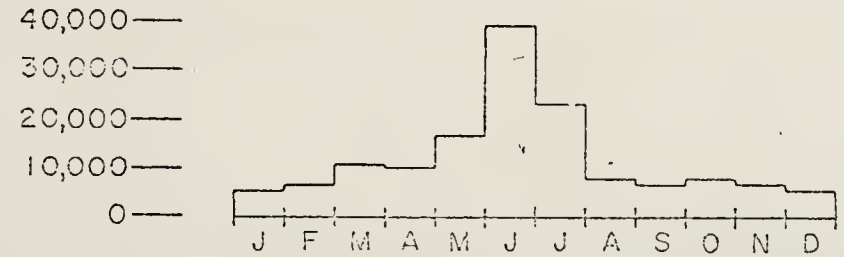
Powder River Near Locate

Low Flow Duration Curves

Period of Record 1939 - 1973







Average Monthly Flow in cfs
for 1941–1970 Base Period

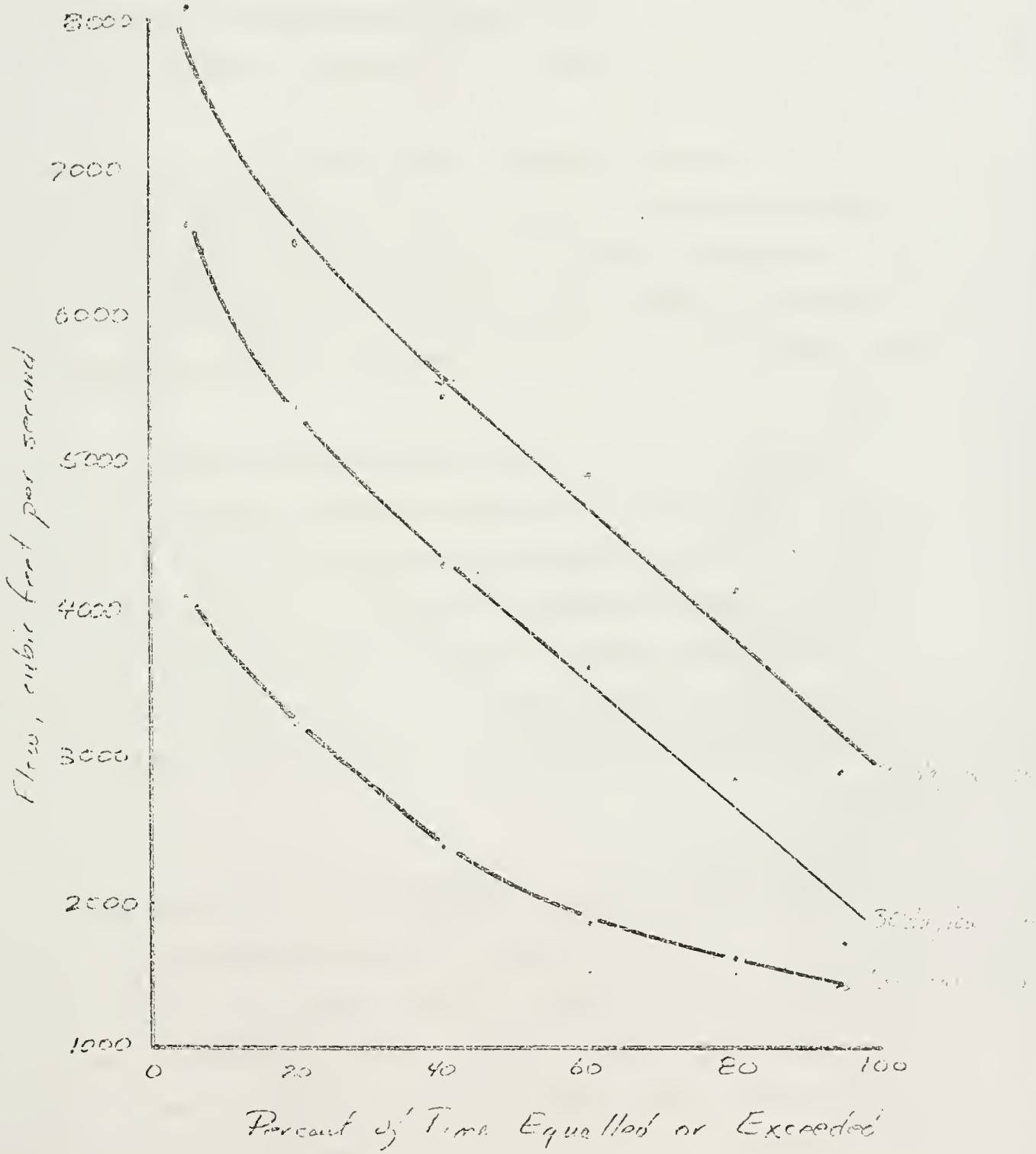
YELLOWSTONE RIVER NEAR SIDNEY

YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06329500
Drainage Area 68812 sq. mi.
Period of Record 1910–1931
1933–Present

YELLOWSTONE RIVER NEAR SIDNEY

LOW FLOW DURATION CURVES

Period of Record 1925-1973



GROUND WATER 1/

Description of groundwater resources is intended to be very general since all water reservation applications are for surface water. Although in many cases surface water is closely linked to ground water levels it is is beyond the scope of this EIS to evaluate that relationship. For descriptive pruposes ground water has been divided between "aquifers near surface" and "deep aquifers".

1. Aquifer Near Surface

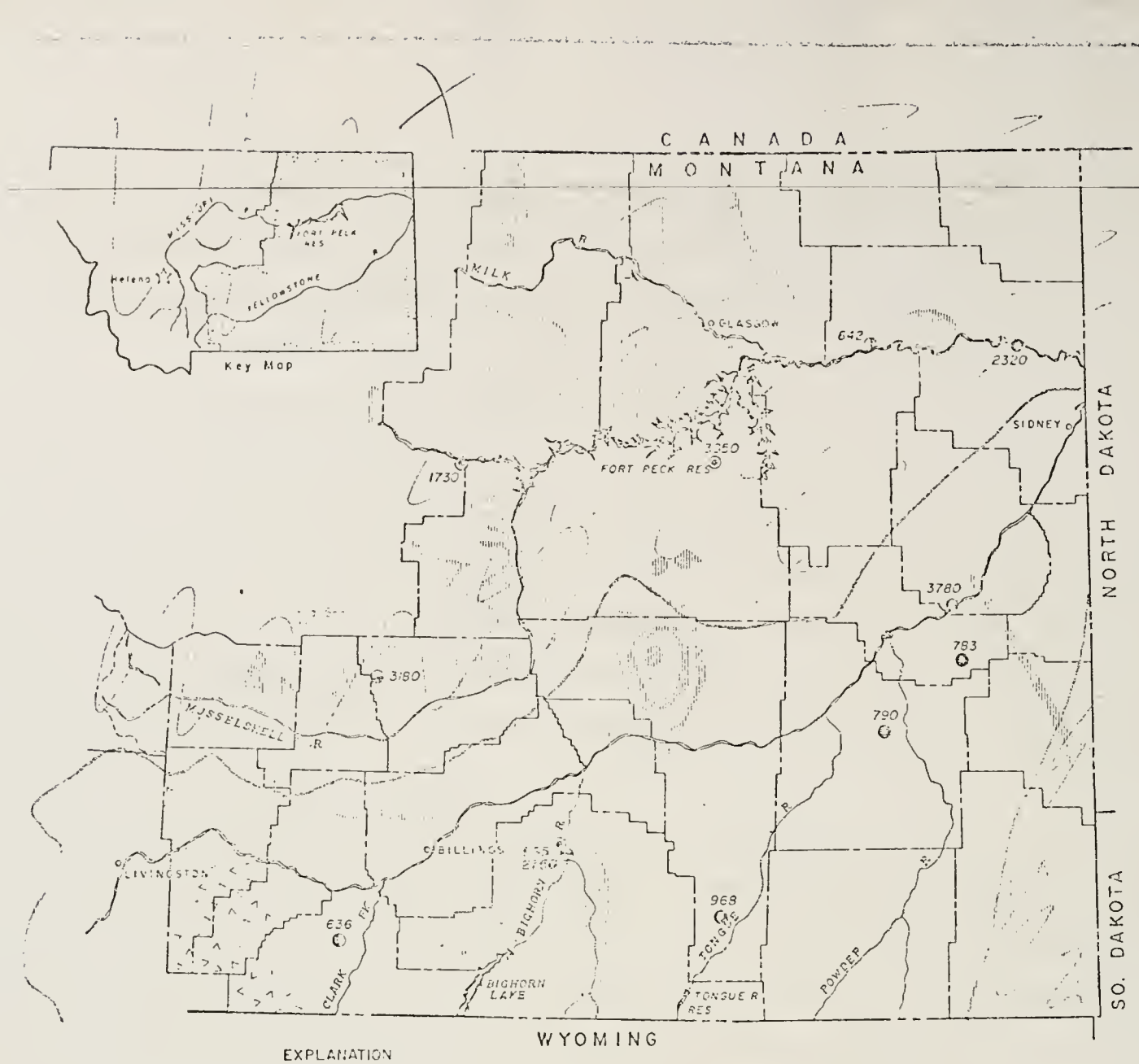
Four characteristic aquifers are shown on Map ____, alluvium, shale, snadstone, and metamorphic and igneous rocks. Unconsolidated sand and gravel along the flood plains and channels of the streams comprise the alluvium. The alluvium is mapped where ~~that~~ drilling and geologic mapping indicate that it is likely to be capable of yielding as much as 1,500 gallons per minute to properly constructed wells.

Shale generally does not yield enough water for domestic or livestock purposes. Sandstone areas include beds of limestone, sandstone, shale, sandy shale, and coal. Water can be obtained from the sandy beds or from the coal beds. Wells tapping the sandstone may produce as much as 50 gallons per minute. Generally, metamorphic and igneous rocks do not store ~~to~~ or transmit large quantities of water. Most of these rocks are fractured, however, and water is sometimes obtained from the joints and faults in these rocks. Well yields normally are less than 5 gallons per minute.

2. Deep Aquifers

~~Rocks of the~~ Of the deep aquifers Mississippian age (rocks) appear to have the greatest potential for water development. The Madison formation, a limestone Mississippian age unit, is a potential source of large amounts of ground water, and some of the water is available under artesian pressure. Map _____ describes generally the pressure surfaces of water within aquifers of Mississippian age. Where the pressure surface is higher than the land surface, water will flow at the land surface when the aquifer is

tapped. The wide spacing of the map contours indicate a gentle slope of the pressure surface throughout the basin. Water enters the rocks of Mississippian age in the out crop areas in the mountains and moves in a northeasterly direction.



EXPLANATION

SURFICIAL AQUIFER AND WATER YIELDS

ALLUVIUM - Sand and gravel along the major streams, where shown, the alluvium is capable of yielding as much as 1500 gpm to properly located and constructed wells

SANDSTONE Includes beds of sandstone, limestone, shale, sandy shale and coal, sandstone and coal beds yield water to wells, generally less than 50 gpm

METAMORPHIC AND IGNEOUS ROCKS Generally yields less than 5 gpm to wells

SHALE Generally does not yield enough for stock or domestic supplies

PREDOMINATE CHEMICAL CHARACTERISTICS IN WATER

- Sodium bicarbonate
- Sodium bicarbonate sulfate
- Calcium bicarbonate
- Sodium calcium bicarbonate
- Sodium sulfate
- Calcium sulfate
- Mixed, includes significant amounts of calcium, sodium, bicarbonate and sulfate

636 Dissolved solids, in parts per million

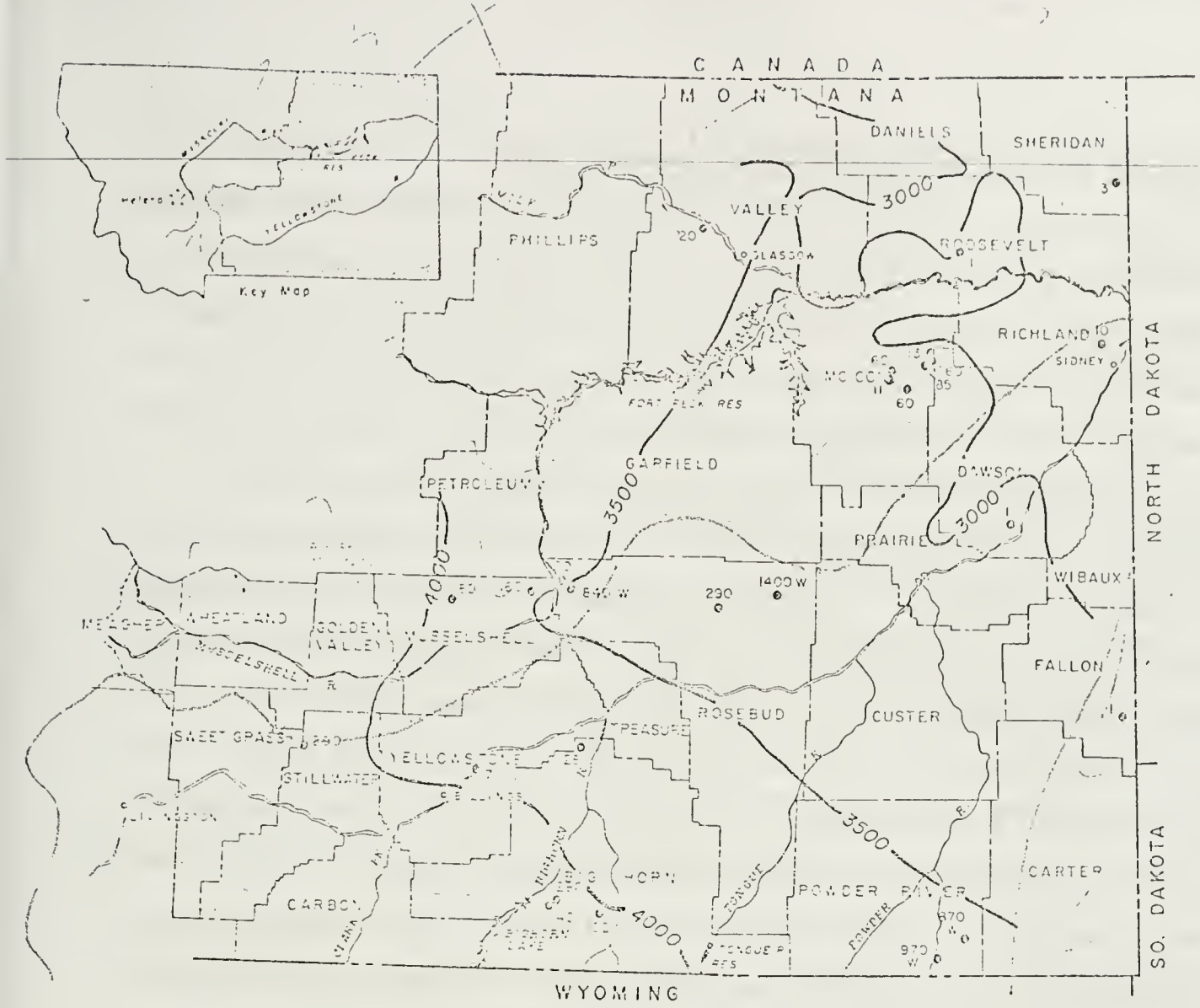
EASTERN MONTANA BASINS

AQUIFERS NEAR SURFACE

INFORMATION SOURCE: B2

SCALE OF MILES 25 0 25 50 75

1237-604-46



EXPLANATION

— 3500 — GENERALIZED CONTOUR SHOWING PRESSURE SURFACE OF WATER WITHIN AQUIFERS OF MISSISSIPPIAN AGE, IN FEET ABOVE MEAN SEA LEVEL

● 840 W WELL OR TEST HOLE THAT FLOWED AT LAND SURFACE. NUMBER INDICATES FLOW, IN GALLONS PER MINUTE. W INDICATES WATER WELL

EASTERN MONTANA BASINS

GROUND WATER
PRESSURE SURFACE
MISSISSIPPIAN AGE AQUIFERS

INFORMATION SOURCE

25 0 25 50 75
SCALE OF MILES

1237-604-51

EXISTING WATER QUALITY OF THE YELLOWSTONE RIVER BASIN

According to the water quality standards set by the Montana State Department of Health and Environmental Sciences, the water quality of the Yellowstone River Basin, with the exception of Rock Creek above Red Lodge, is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. The West Fork of Rock Creek will be maintained suitable for use after simple disinfection and removal of naturally present impurities.

In some cases, the water quality standards are not being met at the present time. A major portion of the present pollution comes from non-point sources; mismanaged and erodible soils and irrigation return flows. Other sources include municipal and industrial discharges, flooding and three water quality limited drainages. The three water quality limited drainages are the headwaters of the Gardiner River, headwaters of the Stillwater River, and the lower drainage of the Clarks Fork River.

The existing water quality of the Yellowstone River in this section will be evaluated by reaches of the river. The upper, middle and lower basins will refer to the Yellowstone River mainstem and tributaries from the Yellowstone National Park/Montana boundary to the mouth of the Clarks Fork Yellowstone River, from the Clarks Fork to the mouth of the Tongue River near Miles City, and from the Tongue River to the Montana/North Dakota border respectively. The water quality data evaluated is from the Montana Department of Health and Environmental Sciences "Water Quality Inventory and Management Plans" 1/ and a recent series of water quality runs by the same department. The water quality parameters evaluated includes pH, specific conductivity, dissolved solids, turbidity,

total suspended solids, dissolved oxygen, biochemical-oxygen demand, fecal coliforms, total alkalinity, total hardness, commons and metals.

The graphs of this section (Figures 1 - 6) were drawn up from data gathered by the Montana Department of Health and Environmental Sciences. The data consists of five water quality runs from the Yellowstone National Park/Montana boundary to Cartwright, North Dakota during the period May, 1975 to May, 1976. Each run includes data from eighteen sites on the Yellowstone River mainstem taken within a three day period. The data plotted on the graphs is the extremes of five runs for the various parameters. The graphs do not represent absolute extremes. This data was compared and found to be consistent with other water quality data published in the Montana Department of Health and Environmental Sciences "Water Quality Inventory and Management Plans". Major tributaries to the Yellowstone River are plotted on the graphs to indicate the reach in which their confluence with the Yellowstone River occurs.

General Overview

The water quality of the Yellowstone River Basin varies widely and seasonally from the upper mountainous drainages to the lower plains as a direct result of changes in elevation, vegetation, flows, climate, soils characteristics and irrigation. Dissolved oxygen concentrations remain near saturation levels throughout the entire basin. Higher values up to 13.5 mg/l have been recorded during the colder months while warm weather levels seldom fall below 7.5 mg/l (See Figure 1). This indicates a general absence of major organic pollution. Fecal coliform/fecal strep ratios indicate that a predominance of animal wastes enter the water rather than human contamination. Highest values are obtained in the middle basin, especially between Billings and Huntley. Total dissolved solids concentrations show a general increase from the upper to the lower basins (See Figure 2). The upper basin has relatively low concentrations

with the exception of the Shields River. The major contributors below the upper basin are the Clarks Fork Yellowstone, Big Horn, Tongue and Powder Rivers and many small tributaries of the lower basin. pH values remain fairly neutral throughout the entire basin. Water temperature shows a general warming trend during the summer months (See Figure 3). Cold waters of the upper basin support a cold water trout fisherie while warmer waters of the lower basin provide a limited warm water fisherie. Temperatures range between zero and 25°C. Turbidities show increases for progressive downstream reaches of the river (See Figure 4). Most major increases appear downstream from major tributaries. As can be seen by comparing Figures 4 and 5, total suspended solids follow much the same pattern as turibidities. BOD concentrations are relatively low in the upper basin (See Figure 6). They pick up considerably through the middle basin and fall off in the downstream reaches of the lower basin. Industrial discharges into the Yellowstone River between Laurel and Billings are credited with the increase in the middle basin. This situation has been improving in recent years. Hardness varies between soft to moderately hard in the upper basin and moderately hard to very hard in the lower basin. Some variation occurs with changes in flow. The waters of the upper basin are a calcium-sodium-bicarbonate type which changes to a calcium-bicarbonate type in the lower reaches of the upper basin. Waters of the middle basin are of a calcium-sodium, sulfate-bicarbonate composition. Those of the lower basin are predominantely calcium-bicarbonate-sulfate composition during high flow and calcium-sodium-sulfate during low flow.

(FIGURES 1 THROUGH 6)

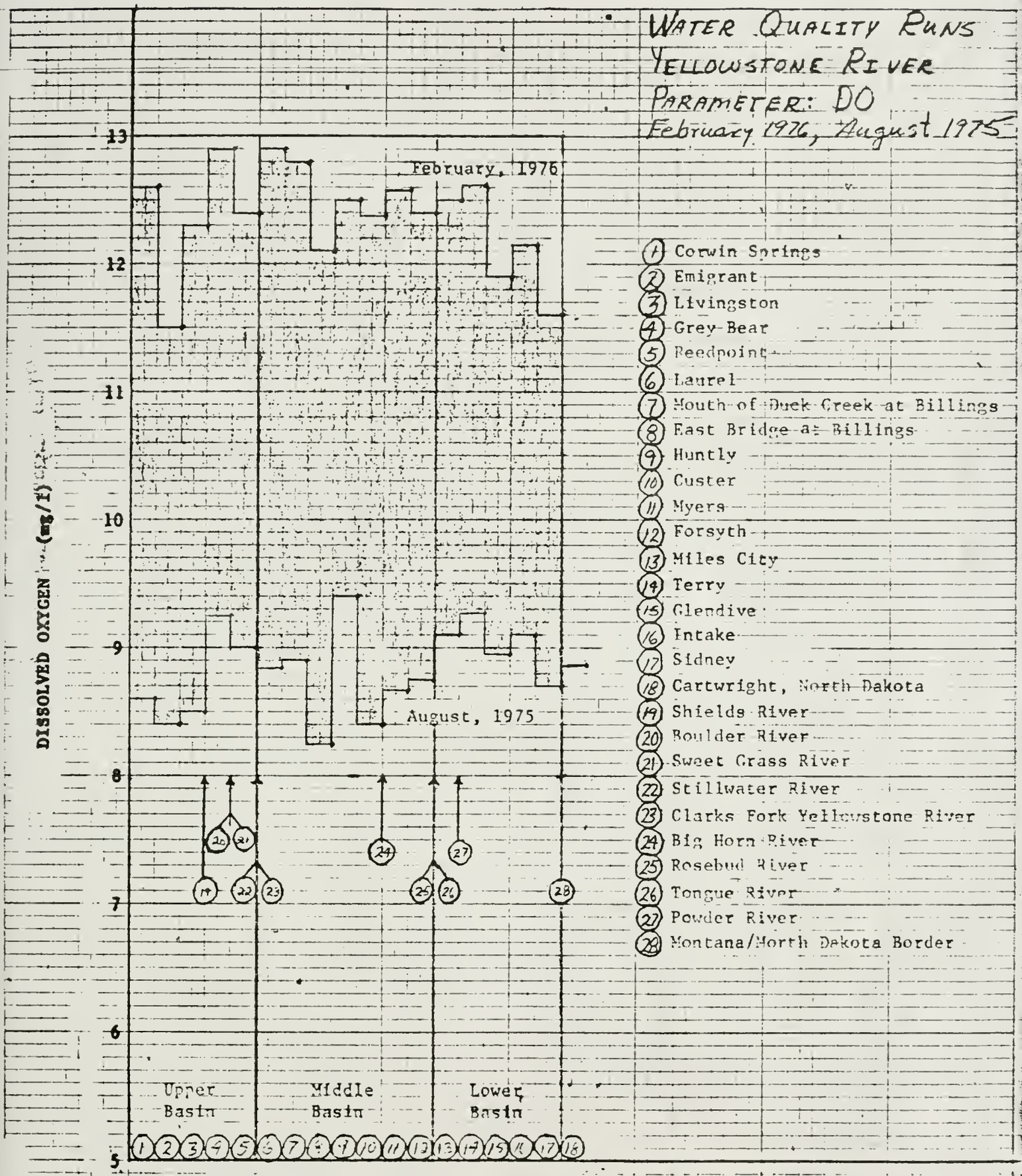
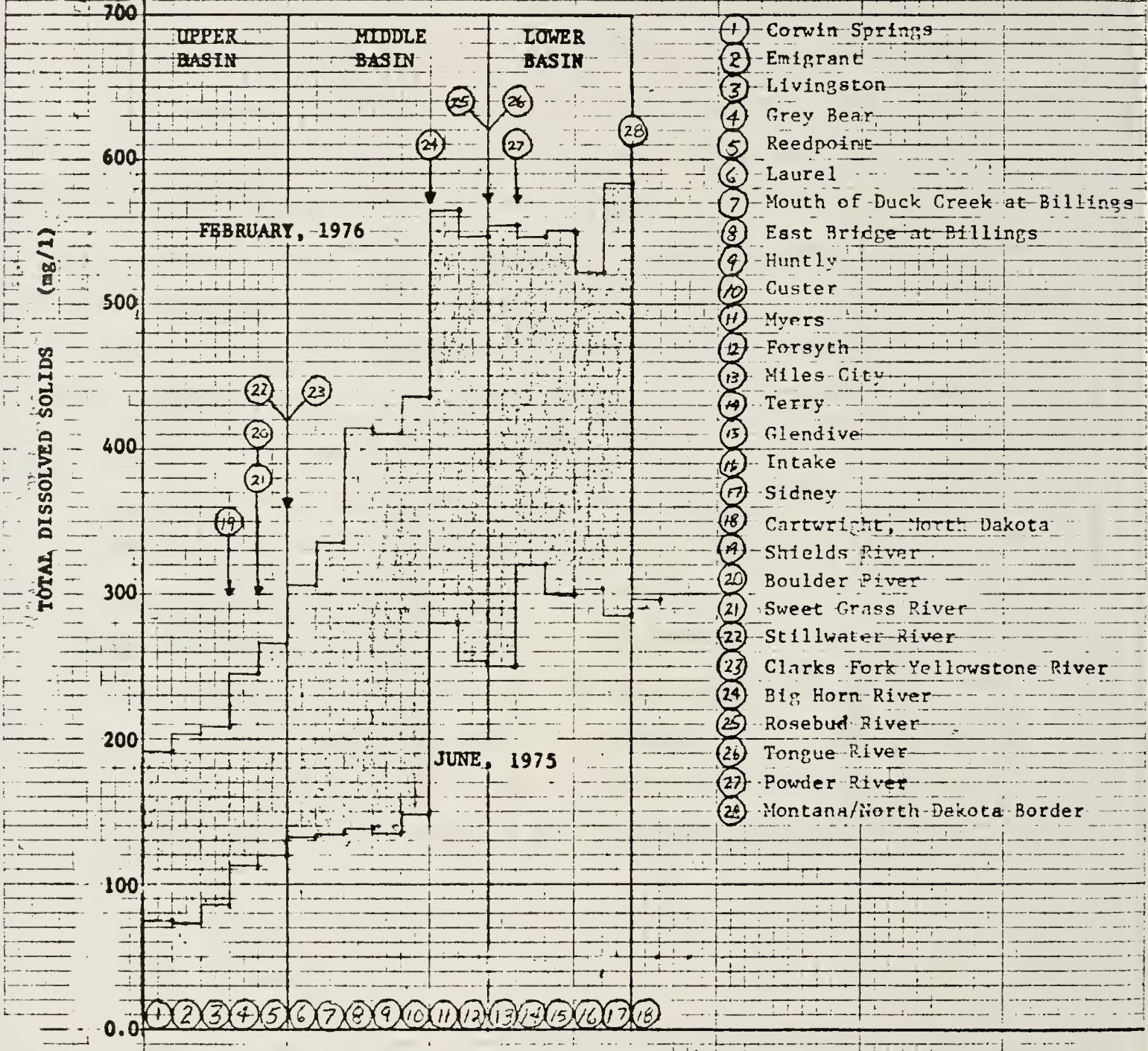


FIGURE 1.

K+E 10 X 10 TO THE INCH 12 5463 NON-REPRODUCIBLE LINES
KEUFFEL & ESSER CO. MADE IN U.S.A.

WATER QUALITY RUNS
YELLOWSTONE RIVER
PARAMETER: TDS
February 1976, June 1975

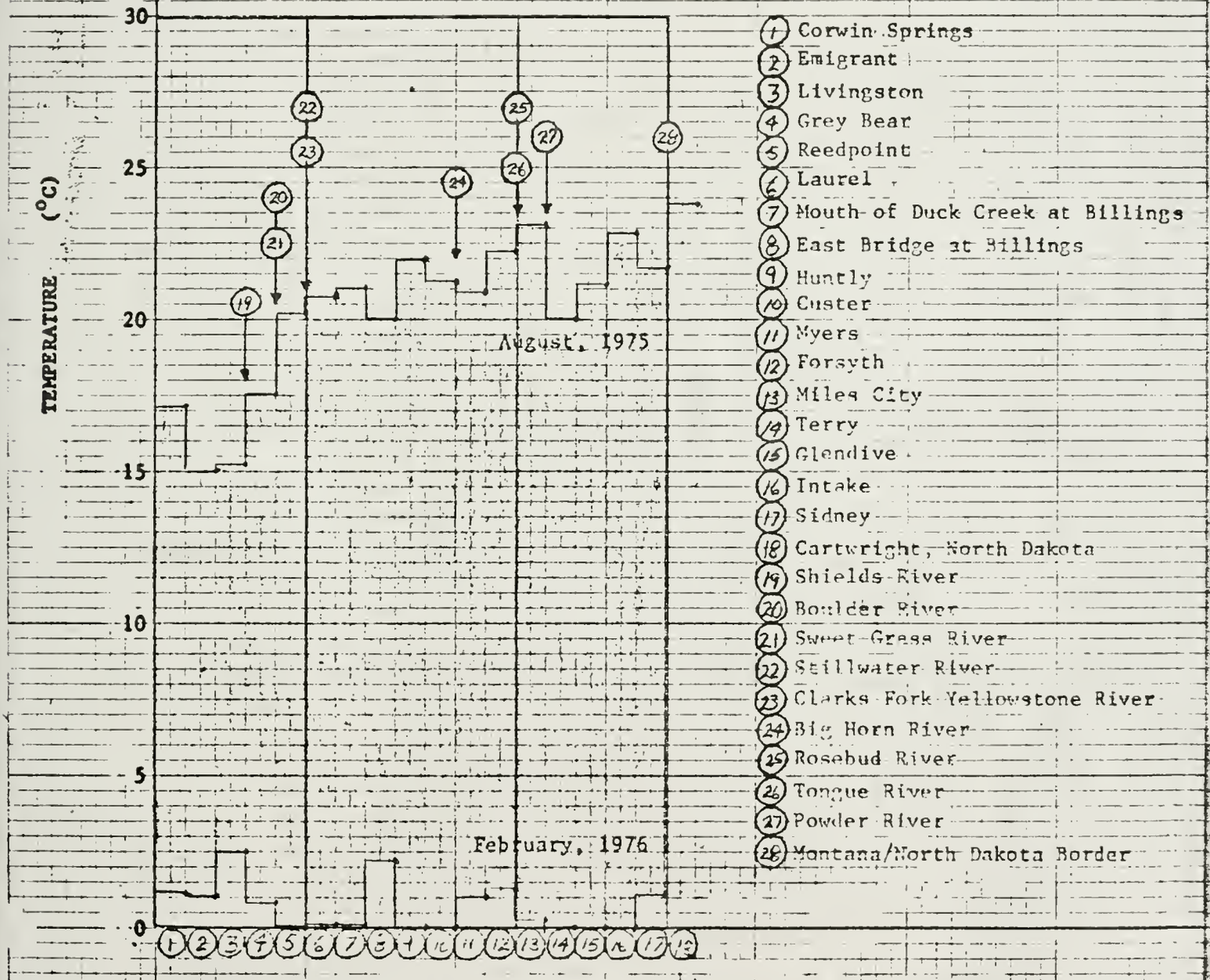


WATER QUALITY STATIONS ON THE YELLOWSTONE RIVER MAINSTEM

FIGURE 2.

K&E 10 X 10 TO THE INCH 12 5465 NON-REPRODUCIBLE LINES
KEUFFEL & ESSER CO. MADE IN U.S.A.

WATER Quality Runs
YELLOWSTONE RIVER
PARAMETER: Temperature
August 1975, February 1976

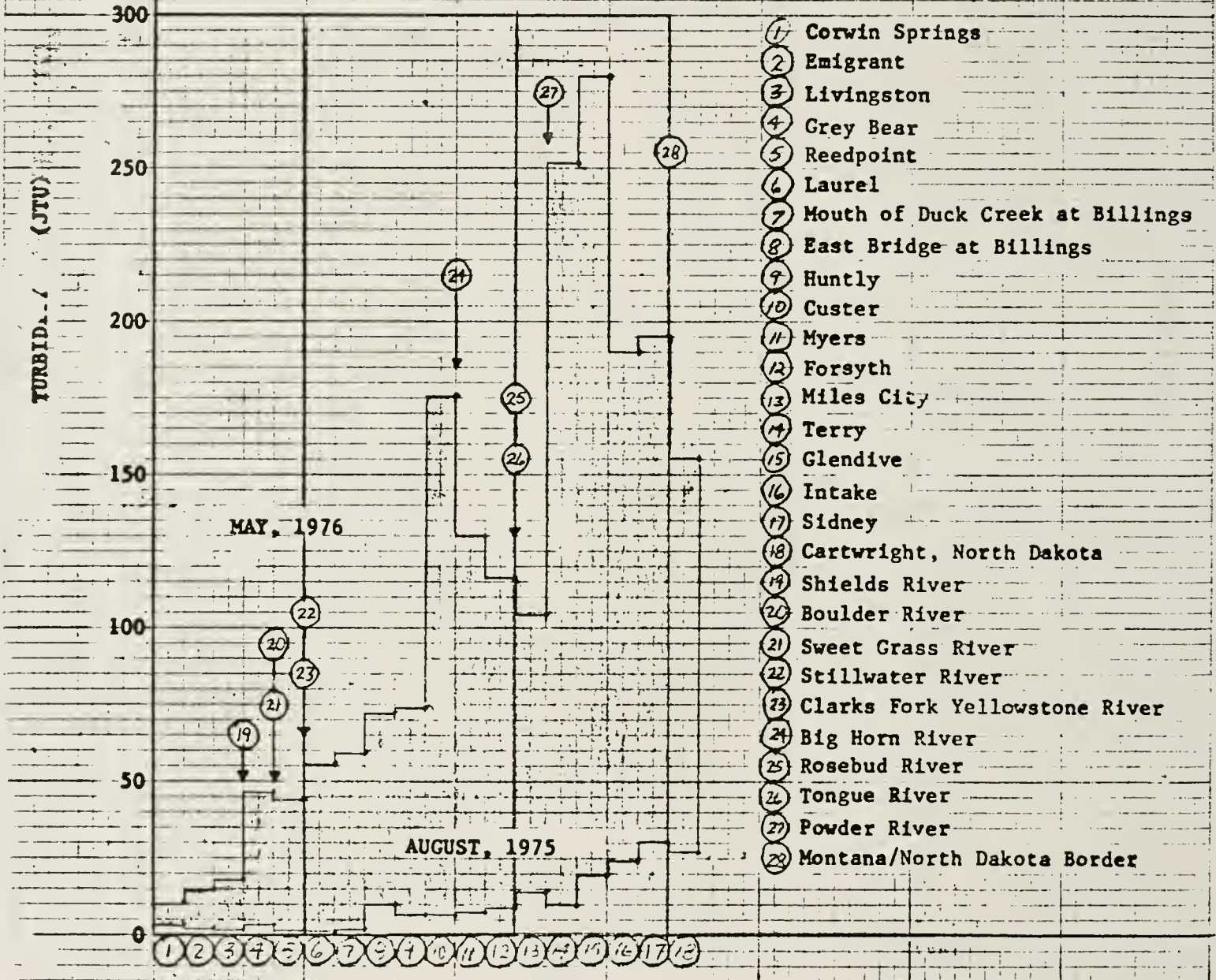


WATER QUALITY STATIONS ON THE YELLOWSTONE RIVER MAINSTEM

FIGURE 3.

K+E 10 X 10 TO THE INCH 12 5468 NON-REPRODUCIBLE LINES
KEUFFEL & ESSER CO. MADE IN U.S.A.

WATER QUALITY RUNS
YELLOWSTONE RIVER
PARAMETER: TURBIDITY
MAY 1976, August 1975



WATER QUALITY STATIONS ON THE YELLOWSTONE RIVER MAINSTEM

FIGURE 4.

10 X 10 TO THE INCH 12 8465
NON-REPRODUCIBLE LINES
KEUFFEL & ESSER CO.

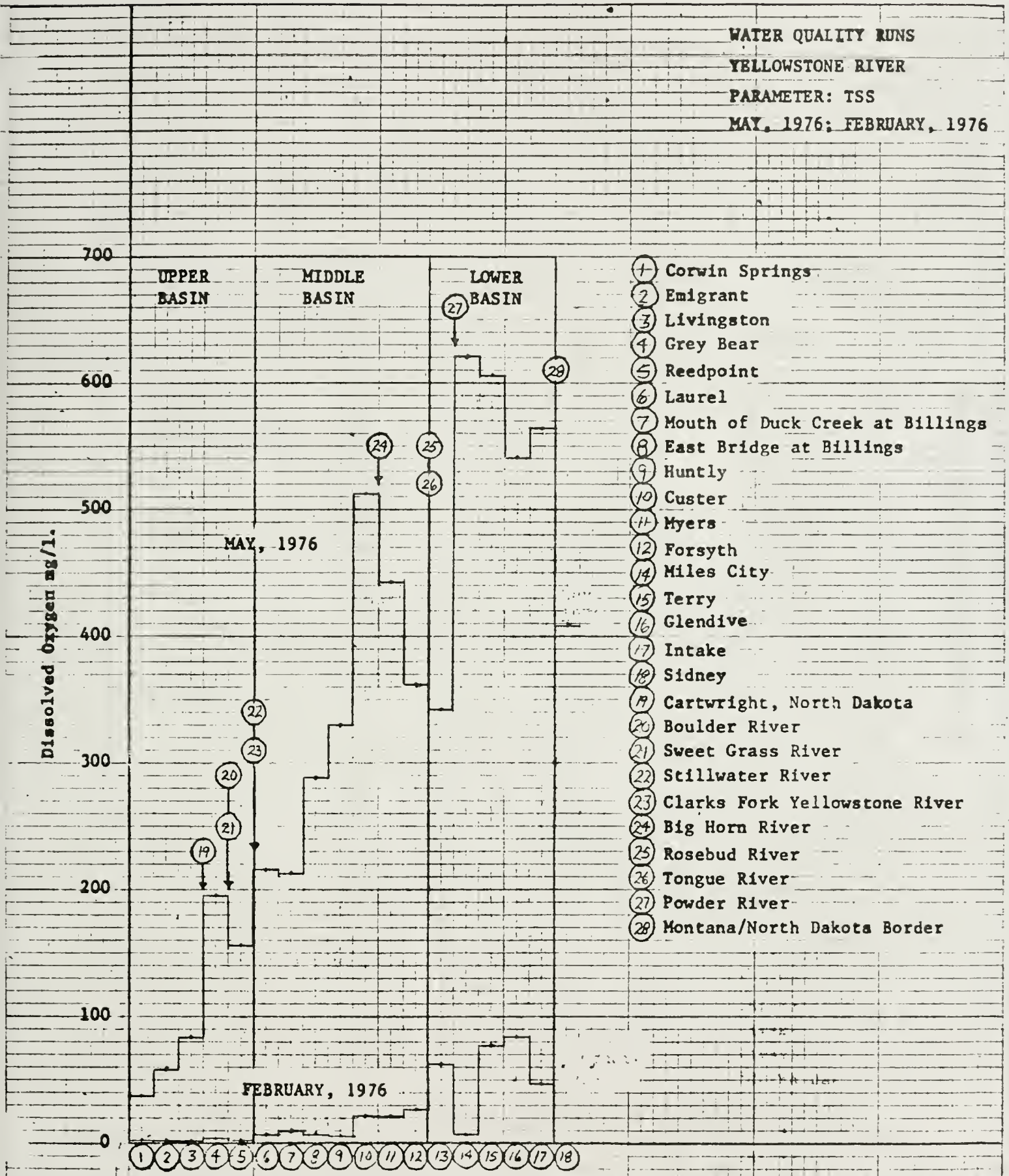
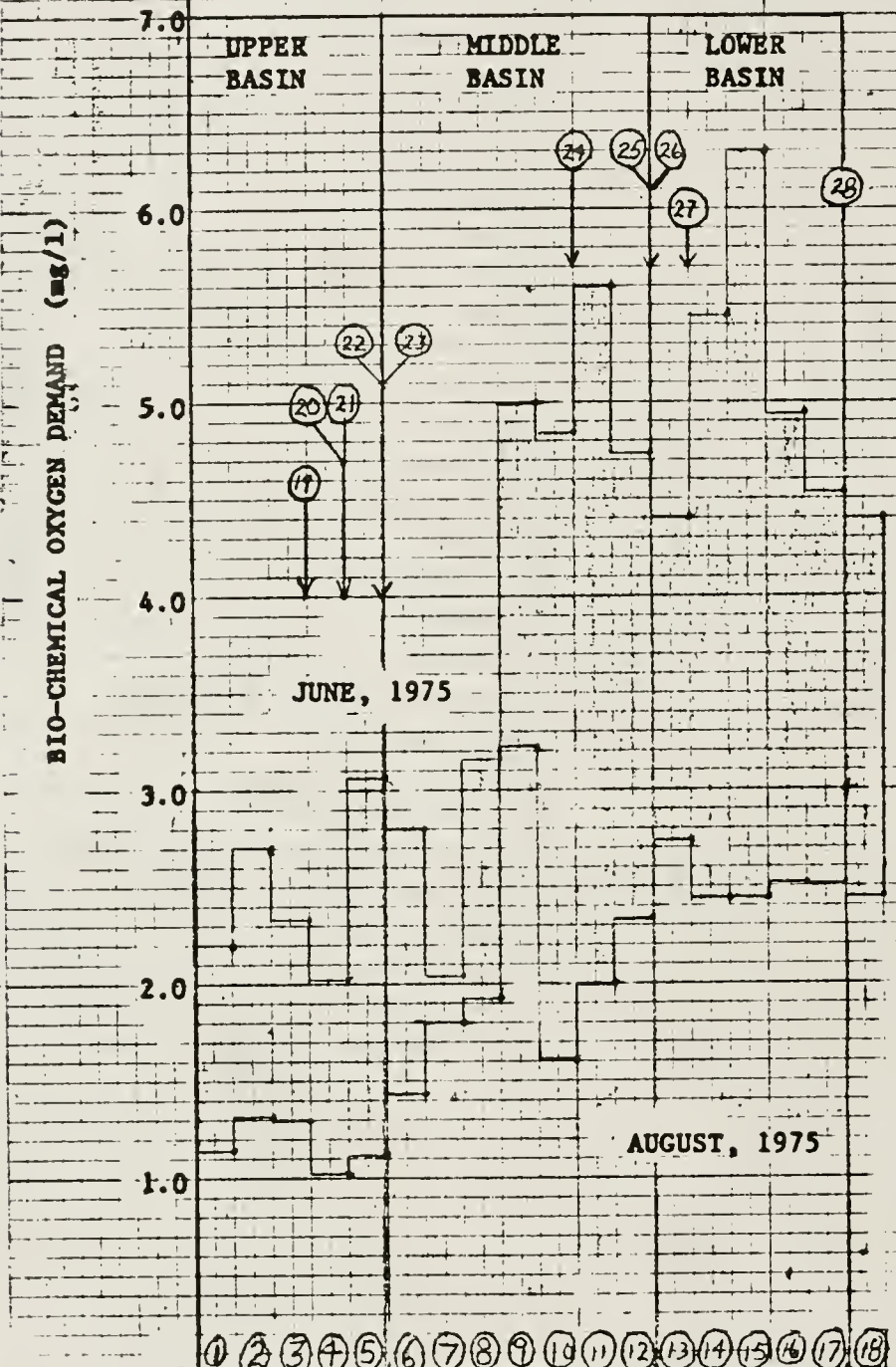


FIGURE 5

10 X 10 TO THE INCH 12 5465
KEUFFEL & ESSER CO.

WATER QUALITY RUNS
YELLOWSTONE RIVER
PARAMETER: BOD
JUNE 1975, Aug 1975



1. Corwin Springs
2. Emigrant
3. Livingston
4. Grey Bear
5. Reedpoint
6. Laurel
7. Mouth of Duck Creek at Billings
8. East Bridge at Billings
9. Huntly
10. Custer
11. Myers
12. Forsyth
13. Miles City
14. Terry
15. Glendive
16. Intake
17. Sidney
18. Cartwright, North Dakota
19. Shields River
20. Boulder River
21. Sweet Grass Creek
22. Stillwater River
23. Clarks Fork Yellowstone River
24. Big Horn River
25. Rosebud River
26. Tongue River
27. Powder River
28. Montana/North Dakota Border

FIGURE 6.

10 X 10 TO THE INCH 12 5465
KEUFFEL & ESSER CO.
MADE IN U.S.A.

Yellowstone River -- Upper Basin

The Yellowstone River of the Upper Basin is a calcium-sodium-bicarbonate type of water with a low concentration of dissolved solids. Calcium and bicarbonate primarily account for an increase in dissolved solids yielding a more calcium-bicarbonate type of water in the downstream reach and during periods of low flow. The water temperature remains fairly constant throughout the year, ranging from zero to 18°C. The dissolved oxygen content remains near the saturation level with variations between 8.4 and 13 mg/l depending on temperature changes. The basin has typically a low BOD concentration and low fecal coliform counts indicating an absence of extensive organic and municipal discharges. Fluoride levels are occasionally greater than threshold concentrations for livestock but not for humans. These high concentrations are attributed to thermal discharges in Yellowstone National Park. The waters of this reach are generally soft to moderately hard. Turbidity and suspended sediment values are generally not high but do show an increase from the Yellowstone National Park boundary to the mouth of the Clarks Fork Yellowstone River.

Major tributaries of the upper basin include Sweet Grass Creek, Lamar River, Shields River, Boulder River, Stillwater River and Clarks Fork Yellowstone River. The waters of these tributaries are calcium-bicarbonate types contributing to the calcium-bicarbonate composition of the Yellowstone River mainstem in the lower reaches of the basin. The tributaries are non-saline and generally soft to moderately hard. The quality of surface water in the basin is generally good, however, three water quality limited segments exist. These are portions of streams where the present water quality is below Montana water quality standards and specified criteria are not expected to be achieved with the application of best practical wastewater treatment and/or secondary treatment

for all point discharges. The headwaters of the Gardiner River is one such stream with excessive amounts of arsenic arising from hot springs. The quality of the Shields River is somewhat inferior to the Yellowstone. Iron and manganese concentrations which often exceed recommended criteria, suspended sediment, turbidity and specific conductance are the major factors contributing to inferior quality. Fecal coliform counts are also relatively high. The water quality of the Boulder River is superior to the Yellowstone River. The water quality of the Stillwater River is classified as good to excellent. Some problems exist however, in the headwaters where acid mine drainage affects alkalinity, pH, and metals concentrations resulting in the Stillwater being another water quality limited segment. These problems are resolved by dillution downstream. The Clarks Fork Yellowstone River waters are of poorer quality than the Yellowstone River. Iron and nitrate concentrations, turbidity and suspended sediment loads are the sources of the poor quality. The Clarks Fork is also a water quality limited segment because of saline seep and siltation in the lower reaches. Suspended sediment loads can exceed 27,000 tons per day during high flows. Silvertip Creek, a minor tributary of the Clarks Fork is of very poor quality. The tributaries of the mainstem in this reach have a significant effect because of the combined volume of their flows.

Yellowstone River -- Middle Basin

The Middle Basin of the Yellowstone River receives the largest municipal and industrial wastewater discharges of the entire Yellowstone River. Irrigation return flows and runoff from barren land results in high sediment and dissolved solids concentrations. The dissolved solids concentrations increase significantly at the confluence of the Big Horn and Tongue River. Through this reach, there is an increase in summer water temperature, resulting in a warm water fishery

downstream. Temperatures range between 25 and 30°C during the summer. Fecal Coliform/fecal strep ratios indicate contamination from animal wastes rather than humans. Streams of this basin are of a calcium-sodium, sulfate-bicarbonate composition. Metals concentrations in this reach are generally less than the permissible criteria set by the Department of Health and Environmental Sciences, with the exception of iron and maganese. These are not considered problem metals as they can be removed by conventional water treatment processes. The waters of this basin are hard to very hard with moderate to high dissolved solids concentrations. Generally, the quality of surface water in the basin can be discribed as poor to fair.

Major tributaries to the Yellowstone River in this basin are the Big Horn River, Rosebud Creek, and the Tongue River. Pryor Creek, a minor tributary, is of comparable quality to the Yellowstone River and therefore has no significant effect on the water quality. The Big Horn River basin is a large natural source of salinity. Runoff from over-grazed lands and saline seep areas carries heavy silt and salt loads. Because of relatively low flows, Rosebud Creek does not degrade the quality of the Yellowstone River significantly even though it has high suspended sediment and dissolved solids concentrations. The Tongue River contributes a large amount of dissolved solids to the Yellowstone River at high flows. A major portion of this is attributed to tributaries of the Tongue River.

Yellowstone River -- Lower Basin

The water quality of the Lower Yellowstone River Basin is closely related to seasonal high flow and low flow periods. The mainstem of the Yellowstone River is predominatly a calcium-bicarbonate-sulfate type of water during high spring flows and a calcium-sodium-sulfate type during low flow periods.

Total hardness varies from moderately hard during high flow to very hard at low flow. Total suspended sediment which shows a general increase in a downstream direction shows and even greater increase during high flows. Specific conductivity values decrease during high flows, but maintain a definite increase in a downstream direction. The concentration of dissolved solids also increases downstream in the Yellowstone River. Water temperatures remain warm with a slight decrease noted from Miles City to Sidney.

Tributary waters of the lower Yellowstone River Basin are of poorer quality than the Yellowstone River mainstem. The only major tributary in this reach is the Powder River. Most tributaries have dissolved solids concentrations, specific conductances, total suspended sediment loads and sodium adsorption ratios that are higher than those found in the Yellowstone River. These waters are moderately hard and are of a sodium-sulfate type. High chloride and strontium levels have been recorded for the Powder River. The geologic formation through which the Powder River flows is the major factor affecting its water quality. Natural runoff produces more salinity and siltation than irrigation return flows. Because of its poor quality, very little use is made of the Powder River for any purpose.

WATER USE

For purposes of this report water use will be segregated into withdrawal and instream uses. Withdrawal use is any use which requires removal of water from a source such as a stream or well. Withdrawal use of water can be classified as either nonconsumptive or consumptive. Much of the withdrawal use is nonconsumptive; that is, the water is taken from its source, used, and eventually returned to the same or another source where it is again available for use. Consumptive use, however, precludes further use of the water because it is evaporated, incorporated into products or crops, consumer by man or animals or otherwise removed from the immediate environment and therefore represents a depletion from the source. Withdrawal uses are grouped into six categories; irrigation, thermoelectric, self-supplied industry, municipal and industrial, livestock, and rural domestic. Water used for irrigation is applied to the land in an effort to grow crops for human or livestock consumption. Basinwide water withdrawn for irrigation use accounts for more than 95% of the total. Thermoelectric water is used for cooling of electric generation plants powered by fossil fuels. While most of the water is used for cooling purposes there is a need for small quantities to use as boiler feed, air conditioning and sanitation. Water obtained from the sources by industry as opposed to that provided by a municipality is referred to as self-supplied industrial water. This use includes water for condenser cooling, processing, washing, conveying, air conditioning, boiler feed, and sanitation. Municipal and industrial water is water provided by a public water supply system and may be publicly or privately owned. The Montana Department of Health and Environmental Sciences define a public water supply as one supplying 10 users or 25 persons. This use includes water for residential purposes and lawn watering,

sanitary purposes, public institutions, military installations, industrial processes, fire fighting and others. Livestock water use was estimated based on farm populations on per capita water consumption of various animals. Rural domestic water is that used by persons not served by a public or municipal water supply system.

Instream uses of water are those which do not require removal of water from the source of supply. The important instream uses in Montana are hydroelectric power generation, recreation, fish and wildlife, and dilution and removal of wastes.

Hydroelectric power generation is considered an instream use even though it is diverted momentarily for passage through turbines. More important when considering other uses for water is the water level that must be maintained in reservoirs for hydropower generation, and also the additional evaporation resulting from that storage. Recreation users and fish and wildlife presently take advantage of almost all of Montana's water, although the actual instream water requirements of those uses are difficult to quantify. Assimilation of pollution is another major use of Montana's water resources.

The study area is divided into the Upper, Middle, and Lower Yellowstone River subbasins to facilitate water use description.

1. Upper Yellowstone River Subbasin

As is true with the rest of the state, water used for irrigation comprises the vast majority of water diverted and consumed in the Upper Yellowstone River subbasin. Table ____ shows the acres irrigated along with water diverted and consumed in this subbasin.

Table ___ WATER USE FOR IRRIGATION

Subbasin	Acres	Diversion Requirement (afy)	Net Depletion (afy)	Return Flow (afy)
Shields River	35,440	209,100	98,280	110,820
Boulder River	8,640	50,980	23,960	27,020
Sweetgrass River	15,880	93,700	44,040	49,660
Stillwater River	26,350	155,470	73,070	82,400
Clarks' Fork Yellowstone River	93,220	550,000	258,500	291,500
Yellowstone River	90,590	534,480	251,210	283,270
Subbasin Total	270,120	1,593,730	749,060	844,670

Irrigation development in this subbasin is almost entirely the result of private enterprise since there are no federally constructed projects in the upper subbasin. Cooney Reservoir was constructed by the Montana Water Resources Board in 1936 and provides 27,400 acre-feet for irrigation use. The primary irrigated crop grown is hay although some corn, sugar beets and beans are raised. Gravity type irrigation systems predominate but recent years have brought increased use of sprinkler irrigation.

The five remaining water uses account for only a very small portion, 5%, of the water withdrawn for use in the basin. Community water systems in the basin withdraw 4.8 million gallons per day (mgd) or 5390 acre-feet per year (afy) of which about half is from surface water, the other half groundwater. Rural domestic use accounts for about 1.1 mgd or 1220 afy. Livestock water use totals about 2.5 mgd or 2800 afy.

The only hydropower reservoir in this subbasin is Mystic Lake on West Rosebud Creek, and since very little water is spilled almost all of the annual flow (average 93,460 acre-feet per year) is used to generate electricity. The plant at Mystic Lake has a capacity of 10 megawatts.

Water remaining in or returning to streams of the Upper Yellowstone River Basin receive heavy use by recreationists seeking fishing, hunting, picnicking, camping, and boating opportunities. These streams also support a high quality and widely diversified fish and wildlife resource. The Recreation and Fish and Wildlife sections of this report describe in general terms those resources.

2. Middle Yellowstone River Subbasin

As in the Upper Subbasin and the rest of the state, irrigation accounts for the vast majority of water diverted and consumed. The water use estimates presented in Table ____ are based on the number of acres irrigated taking into consideration the water typically withdrawn and consumed by crops on one acre of land. While the irrigation season normally extends from April until October, over half the required water is used in the two months -- July and August.

TABLE ____ WATER USE FOR IRRIGATION

Subbasin	Acres	Diversion Requirement (afy)	Net Depletion (afy)	Return Flow (afy)
Pryor Creek	3,360	20,160	9,475	10,685
Shosone River	1,650	9,900	4,650	5,250
Little Bighorn River	18,670	112,020	56,010	56,010
Bighorn River	49,350	296,100	139,170	156,930
Rosebud Creek	1,810	10,860	5,105	5,755
Tongue River	31,180	187,080	87,930	99,150
Yellowstone River	136,700	820,200	385,500	434,700
Subbasin Total	242,720	1,456,320	687,840	768,480

Almost 27,500 acres of the irrigated land are in the Huntley Project, con- by the Bureau of Reclamation in the early 1900's. The project is now maintained and operated by the Huntley Project Irrigation district who have since upgraded several project facilities. The project diverts water from the Yellowstone River to irrigate lands on the south side of the river between Huntley and Bull Mountain. The Tongue River Reservoir, 7 miles northeast of Decker on the Tongue River, built by the Montana Water Resources Board; provides about 64,000 acre-feet of storage for use downstream by irrigators. The dam was constructed in 1939 and is now operated by the Tongue River Water Users Association.

Community water systems in the basin use about 20.1 mgd or 27,520 afy, most of which is consumed in the Billings area. Water withdrawals from the Yellowstone mainstem for once-through cooling of thermoelectric generating plants at Billings total 132 mgd or about 148,000 afy. Of the amount diverted from the river only a very small portion (less than 1%) is consumed. Colstrip units/and 2,350 megawatt coal-fired generating plants, located at the town of Colstrip, will divert and consume about 16,000 afy when fully operational. Self-supplied industries use totals 48.5 mgd or 54,870 afy with most of that being used in the Billins area. Rural domestic and livestock uses are relatively minor, accounting for only about 4,400 afy.

Yellowtail Dam, on the Bighorn River, complete by the Bureau of Reclamation in 1965, houses a powerplant that includes four 62,500 kilowatt generating units that produce an average of about 1 billion kilowatt hours each year. Almost all of the flow of the Bighorn River (average annual: 2.5 million acre-feet per year) is routing through the turbines to produce this power.

As in the other subbasins most, if not all, streams, ponds and lakes, provide for recreation or fish and wildlife use. See sections on those resources for a more complete description.

3. Lower Yellowstone River Subbasin

Most of the water withdrawn from the Lower Yellowstone River subbasin is used to irrigate crops. Table ____ shows the acres irrigated along with estimated of the water diverted and consumed in this subbasin.

TABLE _____ WATER FOR IRRIGATION

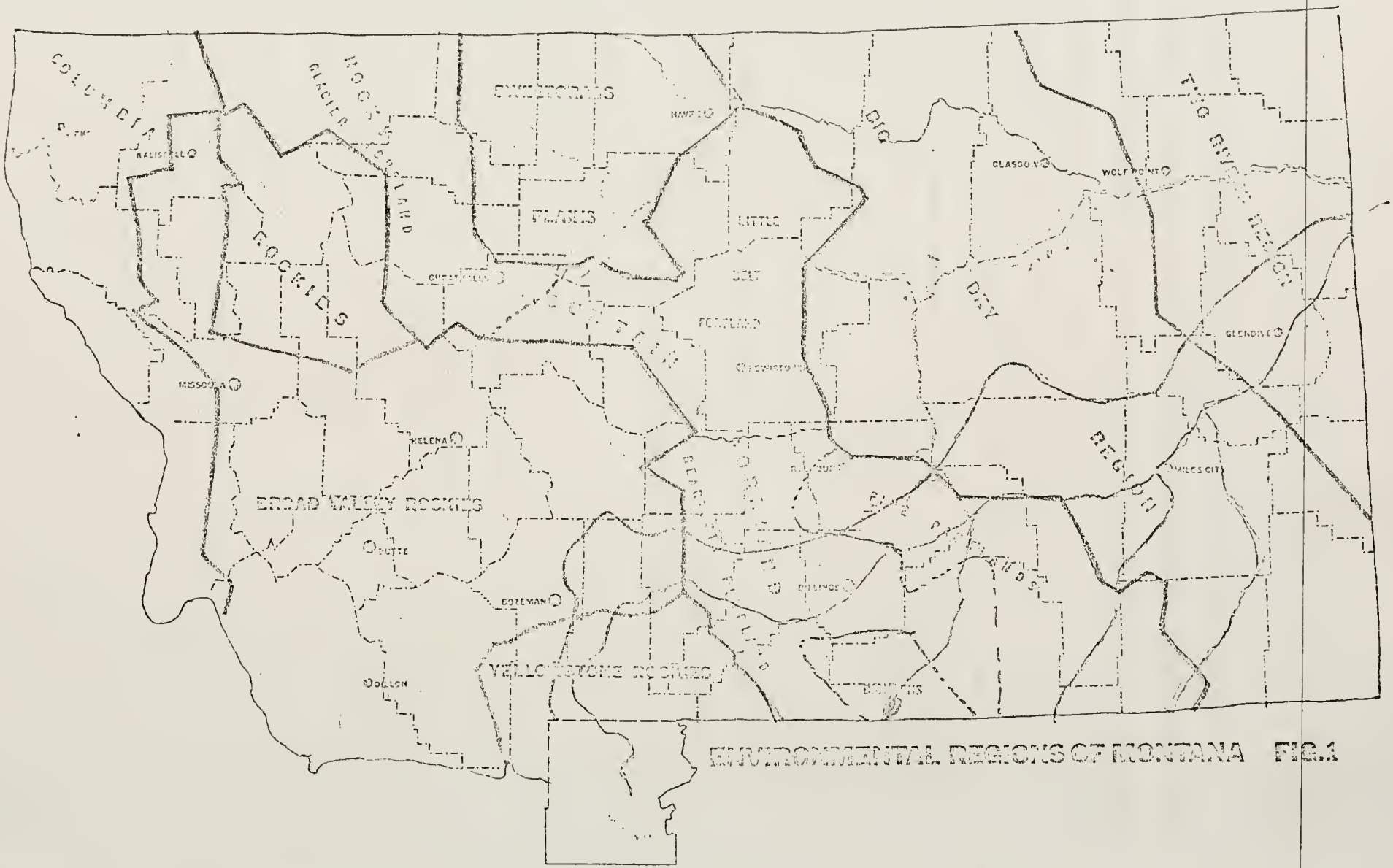
Subbasin	Acres	Diversion Requirement (afy)	Net Depletion (afy)	Return Flow (afy)
Little Powder River	6,785	40,710	19,135	21,575
Powder River	34,055	204,330	96,035	108,295
O'Fallon Creek	4,840	29,040	13,650	15,390
Yellowstone Mainstem	53,330	319,980	150,390	169,590
Subbasin Total	99,010	594,060	279,210	314,850

Bureau of Reclamation projects irrigate a total of almost 70,000 acres and include the Lower Yellowstone Project, Savage Unit, Intake Unit, and the Buffalo Rapids Project. The Lower Yellowstone Project irrigates about 52,000 acres of land extending between Intake and the mount of the Yellowstone River. The project is operated by the Board of Control of the Lower Yellowstone Porject. Intake Unit lies astrice the main canal of the Lower Yellowstone Project about 2 miles from Intake, and is operated by the same board of control. The Savage Unit is west of the Main Canal of the Lower Yellowstone Project in the vicinity of Savage and is also operated by the Lower Yellosteone Board. The Buffalo Rapids Project occupies a bench on the northside of the Yellowstone River between Fallon and Glendive, and a bench on the southside of the river near Terry. The Buffalo Rapids Board of Control operates and maintains the water supply system.

The Sidney Irrigation Project in 1939 was built by the Montana Water Resources Board in 1939 and irrigates about 3,200 acres east of Sidney. The facilities were upgraded by the Soil Conservation Service in 1969 to provide full water supply for those lands.

Water used to cool the gas-fired thermoelectric generation plant at Glendive totals 1.0 mgd or 1,120 afy. The Lewis and Clark coal fired thermoelectric plant at Savage diverts 30 mdg or 33,660 afy. Community water systems in the Lower subbasin withdraw 2.9 mgd or 3,250 afy mainly for the cities of Miles City, Glendive, and Sidney. Rural domestic use totals 1.1 mgd or 1.200 afy. Livestock use amounts to almost 2.1 mgd or 2,375 afy. Self-supplied industry uses about 1.2 mgd or 1,370 afy.

As in the other basins water is used "instream" for recreation, fish and wildlife, and water quality purposes. Sections of this report dealing with those resources present a description of their values in the basin.



ENVIRONMENTAL REGIONS OF MONTANA FIG.1

Aesthetics and Natural Beauty

In the "First Annual Report" the Montana Environmental Quality Council presented a map (see page ____) that segregated the state into environmental regions. These regions were predicated on the concept that macro environments associated with other kinds in a way that usually form a destinctive macro environment. These combinations of macro environments tend to recur throughout a large expanse and form an "environmental region". These regions, in cases, where there are environmental contracts within a region were further disaggregated, for example, the "Bighorns" sector of the "Rocky Mountain Foreland". Description of aesthetics and natural beauty lends itself to this regional delineation since our concept of beauty is based on physical characteristics (slope, vegetation, colors, wildlife, water) upon which the regional segregation was based. This narrative then will honor those boundaries except in a description of the Yellowstone River, since the river disects each of those regions and is an environment crucial to this environmental impact statement.

1. Yellowstone Rockies

"The commanding feature of this region is its majestic mountains which hold more than 25 peaks above 12,000 feet, including Granite Peak, the highest in Montana. Vast reaches of wild secluded land lie behind the great ramparts of the Beartooth, Absarokee, Gallatin, and Madison ranges, which in many places rise almost perpendicular from the valley floors. Glaciers and snowfields ride the flanks of the uppermost peaks, and their waters feed the hundreds of streams and lakes. A special quality of the Yellowstone Rockies derives from its great expanses of alpine and sub alpine plateaus, their sweeping meadows a profusion of wild flowers. It is probable that the last chief of the Crow, Chief Plenty Coups (1848-1932), had these mountains in mind when he said

> of all things created, the mountains only have escaped the domination of the white man. The valleys are scarred by the plowman, ridged by the trailmaker and guttered by the taker of water, but the mountains are still as God made them, and to be near them is to be on the pathway to peace.

PICTURE OF PARADISE VALLEY
OR
BEARTOOTH PLATEAU

Although the natural landscape of the Yellowstone Rockies is increasingly modified by human activities, an environment of such high quality persists in that name "Paradise", given to a portion of the upper Yellowstone Valley, is still not inappropriate for the region as a whole"[1/]

The region in the Yellowstone River drainage is composed primarily of the Paradise Valley, east side of the Gallatin Range, the Beartooth Plateau, and the Absarokee Range. It also contains portions of the Gallatin and Custer National Forest

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1/ First Annual Report, Montana Environmental Quality Report, June 30, 1972.

and includes the Absarokee and Beartooth Primitive Areas and many thousands of additional acres of undesignated wildland qualify for inclusion in the National Wilderness Preservation System.

Intrusions that have disrupted the ecological stability and aesthetic character of the region include elimination of large predators, preemption of winter game range by human settlement, the Beartooth Highway, off-road vehicle use, livestock overgrazing, and others that inevitably occur with human encroachment.

2. Beartooth Foreland

"Backed by the grandeur of the Beartooth Plateau, spreading outward into river valleys and to other mountain ranges, is a warm and welcoming landscape. Its beauty and livability were eloquently described by the Crow Chief Arapooish:

> The Crow country is a good country. The Great Spirit has put it exactly in the right place, when you are in it you fare well; whenever you go out of it, whichever way you travel, you face worse...The Crow country is exactly in the right place. It has snowy mountains and sunny plains; all kinds of climates, and good things for every season. When the summer heat scorches the prairies, you can draw up under the mountains, where the air is sweet and cool, the grass fresh, and the bright streams come tumbling out of the snowbanks...

PICTURE OF PLAINS NEAR HARDIN

The Beartooth Foreland differs from other foreland regions in its topography and land use. It contains more of the outlying mountain ranges and has gentler croplands more conducive to dryland farming. It is not a "soft" landscape, however, for high hills twist toward the mountains, and streams have cut through overlying sandstone formations to form precipitous bluffs, the best known of which are the rimrocks at Billings."1/

As shown on Map ____ the Beartooth Foreland extends from Red Lodge and Big Timber on the west through Billings and Hardin to the east. While the region does not include any national forests, existing or potential wilderness areas, it does have a number of significant historic sites. A number of streams, including the Bighorn River, Clarks Fork River, Yellowstone mainstem, Rock Creek, Rosebud Creek, and Pryor Creek, provide a welcome contrast to the grassy plateaus and rocky sparsely timbered hills and give the Beartooth Foreland an unusual diversity of open space.

Intrusions into the Beartooth Foreland include the Billings urban sprawl, overgrazing, irrigation, transportation facilities and other attendant effects of human influx.

1/ First Annual Report, Montana Environmental Quality Council, June 30, 1972.

3. Bighorns

> "The country belonging to the Crows was not only beautiful, but it was the very heart of the buffalo range of the Northwest. It embraced endless plains, high mountains, and great rivers, fed by streams clear as crystal. No other section could compare with the Crow country, especially when it was untouched by white men. Its wealth in all kinds of game, grass, roots, and berries made enemies for the Crows, who, often outnumbered, were obliged continually to defend it against surrounding tribes.

The Bighorns subregion of the Rocky Mountain Foreland is a uniquely beautiful part of Montana and the center of Crow country, encompassing the bold forested Pryor Range on the west, the nearly spend grassy northern extremities of the Bighorns on the east, and the spectacular gorge of the Bighorn River between. It is an area that appeals to all the senses and any or all conceptions of environmental attractivness. In no other place in the state, within a distance of 15 miles and an elevational change of 5,000 feet, do vegetional types range from true desert shrub to subalpine forest and meadow. Although the smallest of the environmental regions and subregions in both population and size, it is perhaps the richest in Indian Legend and religion."1/

PICTURE OF YELLOWTAIL RESERVOIR

1/ First Annual Report, Montana Environmental Quality Council, June 30, 1972.

The Bighorn subregion extends from the Pryor Mountains on the west to the Bighorn Mountains to the east, with the Bighorn River cutting a canyon in the middle. Yellowtail Reservoir while inundating several thousand acres of important winter game range in the Bighorn Canyon provides flat water recreation on the lake and an excellent trout fishing downstream.

Some of the intrusions are Yellowtail Reservoir, overgrazing, and off road vehicular use.

4. Pine Parklands

"This Foreland subregion is a golden land, a land of buff-colored sandstone cliffs, ochre-tinted ponderosa pine bark, and expanses of yellow grass. The landscape seems to glow under the hot summer sun. It is intimate - with a feeling of closeness between man and earth. In his travels in 1880, Granville Stuart commented on the intrinsic quality of the Parklands:

> We are passing through what is called the canyon where the Rosebud cuts through the Big Wolf Mountains, but it is not much of a canyon, being never less than one mile wide and with beautiful little grassy vales extending back among the picturesque castilated red buttes which have considerable nice yellow pine scattered over them...buttes and bastioned fortresses of all shapes and sizes capped and often landed with broad belts of vivid red scoviacious shelly rock, crowned with beautiful clumps of yellow pine trees and in many of the glades and sags are fine groves which add much to the beauty of the scene and where burned off, the hills are green with new grass (5).

The topography of the subregion reflects the variability of the underlying sedimentary strata. It consists of broad rolling uplands, angular sandstone-capped buttes and spurs, and deeply dissected badlands where shale beds have been exposed to running water. The northern and southeastern portions are characterized by low hills covered with dense growths of ponderosa pine. Elsewhere trees are generally restricted to the coarse, poorly developed soils associated with sandstone outcrops. To the south the presence of coal is ever more apparent as it begins to appear in outcrops and the colorful clinker-capped ridges become the distinguishing feature of the landscape. Clinker or scoria is a red sedimentary rock fused or baked by heat rising from smoldering coalbeds. These beds more effectively resist erosion than most unaltered sediments and thus remain topographically high when exposed."1/

1/ First Annual Report. Montana Environmental Quality Council, June 30, 1972.

PICTURE OF COLSTRIP

The Pine Parklands subregion extends from Forsyth on the north, southward past Lame Deer to the Montana-Wyoming border. Part of Custer National Forest comprises a good share of the subregion, with private land and the Northern Cheyenne Indian Reservation making up the remainder.

Instrusions that disrupt the ecological integrity of the subregion include coal strip mining, overgrazing, logging, and highway construction. The Tongue River Reservoir while inundating _____ acres of land provide a source of flatwater recreation that is heavily used to the point of abuse in some areas.

5. Big Dry Region

"The Big Dry might have been what some early day explorers had in mind when they named that interior portion of western America the "Great American Desert". This part of Montana, however, can be conceived of as a desert only in contrast to the pleasantries and verdure to which our European forefathers were accustomed. Today it remains largely unsettled, even by Montana Standards."[1/] The average population for the counties of Carter, Custer, and Prairie is about one person per square mile.

The region includes a portion of the Yellowstone with Miles City at its center and a good part of the Powder River Basin. Subject to weather extremes and a shortage of natural rainfall the area is still not a wasteland but is productive rangeland and supports dry land wheat farming. Overgrazing can be a serious problem since many areas have soils highly susceptible to erosion. Other intrusions are urban buildup, transportation facilities and irrigated cropland.

1/ First Annual Report, Montana Environmental Quality Council, June 30, 1972.

6. Two Rivers Region

"The two rivers, the Missouri and its first major tributary, the Yellowstone, converge across Montana from the west and southwest to their confluence near the present northeastern border of the state. These waterways were vital avenues for exploration of the early-nineteenth-century frontier and, for nearly 100 years thereafter, for settlement and commerce. Captain Lewis recorded his impressions of the area on April 28, 1805, shortly after the Corps of Discovery passed the mouth of the Yellowstone on its westward journey:

> ...The country on both sides is much broken, the hills approaching nearer to the river and forming bluffs, some of a white and others of a red color, exhibiting the usual appearances of minerals, and some burnt hills, though without any pumice stone; the salts are in greater quantities than usual and the banks and sandbars are covered with a white incrustation like frost. The low grounds are level, fertile, and partially timbered, but are not so wide as for a few days past. The woods are now green, but the plains and meadows seem to have less verdure than those below...Game is very abundant-the common, and the mule or black-tailed deer, elk, buffalo, antelope, brown bear, beaver, and geese. The beaver have committed great devastation among the trees, one of which,nearly three feet in diameter, had been gnawed through by them(1)."1/

PICTURE OF MAKOSHIKA PARK

1/ First Annual Report, Montana Environmental Quality Council, June 30, 1972.

While Lewis was referring to lands along the Missouri the Lower Yellowstone is aptly described by his narrative. This region includes the portions of Dawson, Richland, and Wibaux Counties in the basin.

The open prairies, river bottoms, brushy draws, and wetlands provide a wide variety of habitat for game birds and mammals, however some of this habitat has been drastically altered by intensive agriculture. Dust is a problem throughout much of the region, some of it the result of overworking soils with farm machinery.

7. Yellowstone River

The Yellowstone River has survived as one of the last large free flowing river systems in America, the lack of impoundments leaving the spring peak flows and fall and winter low flows to establish a unique ecosystem and aesthetic resource that defies adequate description. The river, from the clear cold cutthroat trout fishing in Yellowstone National Park to the warmer meandering paddlefish habitat at its mouth, displays a variety of aquatic environments that have remained relatively undisturbed when compared to the Missouri, Platte, or Colorado. The adjacent terrestrial environment, through the 550 miles of river, is classified as bottom land cottonwood-willow as shown on Map _____. Captain Clark's diary of July 27th 1806, written during travels down the Yellowstone with other members of the Lewis and Clark Expedition provides a vivid description of the river below the mouth of the Bighorn River as it was 170 years ago.

> The Buffalow and Elk is estonishingly noumerous on the banks of the river on each side, particularly the Elk which lay on almost every point in large gangs and are so jentle that we frequently pass within 20 or 30 paces of them...much more beaver Sign than above the bighorn (River). When we pass the Big Horn I take my leave of the View of the tremendous chain of Rocky Mountains white with snow...this river below the big horn river resembles the Missouri in almost every perticular except that it's islands are more noumerous & falling in the bottoms. On the Star Side low and extensive and covered with timber near the river such as Cotton wood willow of the different species rose bushes and Grapevines together... on the Lar Side the river runs under the clefts and Bluffs of hish which is from 70 to 150 feet in hight...1/

1/ Original Journals of the Lewis and Clark Expedition, 1804-1806, Volume Five Part II, Rueben Gold Thwartes, 1905.

Rip rap, sewage effluent, urban development, cottonwood clearing and diking have modified the Yellowstone since that time but it still provides a tranquil repast for those who take the time to float the riffles or walk the bank.